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EVALUATION OF FEEDING PREFERENCE AND POTENTIAL OF PHYTOSEIID PREDATORY MITE *NEOSEIULUS LONGISPINOSUS* (EVANS) ON DIFFERENT STAGES OF *TETRANYCHUS MACFARLANEI* BAKER & PRITCHARD

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ABSTRACT

The prey stage preference and feeding potential of active stages of the predatory mite *Neoseiulus longispinosus* (Evans) were studied under laboratory condition 23±1°C to 28±1°C and 70-80% RH using lifestages of *Tetranychus macfarlanei* (Baker and Pritchard). Prey stage preference was studied by providing known number of prey stages together on a leaf bit where, larva of predator did not consume any prey stage. Protonymph and deutonymph exhibited preference towards larval and nymphal stages of the prey whereas, adult predator showed preference for larval stage followed by eggs and nymphal stages. In feeding potential study, predator was offered prey stages individually. Protonymph and deutonymph consumed 2.40 and 4.00 eggs, 3.40 and 4.70 larvae, 1.60 and 3.20 nymphs and 0.20 and 0.20 adults of the prey, respectively and the adult predator consumed a mean of 159.00 eggs, 171.60 larvae, 94.20 nymphs and 19.20 adults of prey in its lifespan.

Key words: *Neoseiulus longispinosu*s, lifestages, phytoseiid, predator, prey tetranychid, *Tetraanychus macfarlanei*, consumption, preference, phytophagous, resistance, biocontrol, ecofriendly, feeding

Phytophagous mites are more problematic pests in the recent years due to intensive agricultural practices and high input production systems. Among phytophagous mites Tetranychidae is the most injurious group on several crops and ornamental plants-Kasap and Atlihan (2011). The carmine spider mite *Tetranychus macfarlanei* Baker and Pritchard is one of the most important pests of vegetable crops (Jeppson et al., 1975); also reported from medicinal plants like *Clitoria ternatea* L. and *Justicia adhatoda* L. Nees in India (Gupta, 2005). It was reported causing severe damage on okra in parts of Karnataka, Kerala, Gujarat, Punjab and West Bengal in India (Zeity, 2015). Spider mites have developed resistance to acaricides, making chemical control ineffective or less effective and leaving dangerous residues (Vassiliou and Kitsis, 2013; Simmons and Jackson, 2000). This also make biocontrol an effective and environmentally friendly approach for managing spider mite pests. Because of short lifecycles and high reproductive potential, phytoseiid mites are effective biocontrol agents. Important species of phytoseiid mites used in biocontrol programs include *Phytoseiulus persimilis* Athias-Henriot, *P. macropilis* (Banks), *Amblyseius swirskii* (Athias-Henriot), *Amblyseius andersoni* Chant, *Galendromus* (=*Typhlodromus*, =*Metaseiulus*) *occidentalis* Nesbitt, *Kampimodromus aberrans* (Oudemans), *Typhlodromus pyri* Scheuten, *Euseius finlandicus* (Oudemans), *E. hibisci* (Chant), *Neoseiulus californicus* (McGregor), N. cucumeris (Oudemans), *N. fallacis* (Garman), *N. barkeri* Hughes and *N. longispinosus* (Evans) etc. of which *N. longispinosus* is the most important indigenous species proven to be an effective predator of tetranychid mites (Mallik, 1975).

Evans described the *Neoseiulus longispinosus* from Indonesia in 1952. Schicha (1975) from Australia produced a redaction after which it was separated from its closely related species *Amblyseius womersleyi* (Schicha). *Neoseiulus longispinosus*, a well-known biocontrol agent is employed commercially to eradicate spider mites and is revered as a benediction to phytoseiid mites (Bhowmik and Yadav, 2020). Few studies on feeding potential and preference have been carried out globally. The purpose of the current study was to better understand the feeding potential and preference of the predatory mite *N. longispinosus* on spider mite *T. macfarlanei*.

MATERIALS AND METHODS

The experiment on feeding preference and potential was conducted at the College of Agriculture, University of Agricultural Sciences, GKVK, Bangalore during 2019-2020 under the laboratory conditions. Prey mite

T. macfarlanei was mass reared on excised mulberry leaves placed on wet foam in polyethylene trays and small nucleus culture of the predatory mite was taken from the polycarbonate house of All India Network Project on Agricultural Acarology, University of Agricultural Sciences, GKVK Campus, Bengaluru, Karnataka and further reared on spider mite infested detached French bean leaves placed on wet foam in polyethylene trays. The feeding preference by individual larvae, protonymph, deutonymph and adult predatory mites was studied by placing a known number of each prey mite life stage i.e., egg, larva, protonymph, deutonymph and adult together on a mulberry leaf bit. Fresh mulberry leaves were chopped into 2 cm^2 each pieces and arranged abaxial side up on wet foam in trays and thirty replications were created using thirty leaf bits. As the feeding requirement of different life stages of the predatory mite varied, the number of prey stages offered to each feeding stage of the predatory mite was decided so that the number offered was always in excess of what consumed. In case of the immature lifestages of the predatory mite the prey consumed in the respective stages and for the adult predatory mites, the prey consumed in 24 hr period was recorded.

To know the number of prey mites a predatory mite could consume in its lifestages individually and in its entire lifespan starting from larva to the end of the adult stage, five treatments were used. In the first treatment, the predatory mites received only the prey mite eggs, the larval stages in the second, nymphal stages in the third (protonymph + deutonymph), adult stages in fourth, and all four stages combined in the fifth treatment in equal numbers. One neonate larva of the predatory mite and a known number of prey stages from treatments were added to each leaf bit. The predatory mite was allowed to feed on prey mites during its developmental period and adult hood till it died naturally. The experiment consisted of ten replications for each treatment. Observations were recorded on the number of each prey stages consumed by the predatory mite in its larval, nymphal and adult stage at 24 hr interval until its natural death. Data obtained for prey preference and feeding potential of the predatory mite were subjected to statistical analysis by SPSS software version 23.0. Minimum and maximum consumption, mean total consumption were calculated, and prey preference was compared using one-way ANOVA followed by Tukey's HSD test ($p<0.01$).

RESULTS AND DISCUSSION

The number of *T. macfarlanei* prey stages consumed by active lifestages of predatory mite, *N. longispinosus* are presented in Table 1. The larva was a non-feeding stage and did not consume during its mean lifespan of 15.70 hr. Hegde and Patil (1994) also observed the non-feeding behaviour of larval stage of the

Table 1. Feeding preference of life stages of predatory mite *N. longispinosus* for life stages of prey mite *T. macfarlanei*

Feeding stages of predatory mite	Prey mite stages offered together	Mean number consumed			Ne/No
		Mean± S.E.	Min.	Max.	
Protonymph (lived for 26.24 h)	Egg	0.40± 0.12[ab*]	0	2	0.13± 0.04[ab]
	Larva	1.13± 0.11[c]	0	2	0.37± 0.03[c]
	Protonymph	0.76± 0.11[bc]	0	2	0.25± 0.03[bc]
	Deutonymph	0.66± 0.11[bc]	0	2	0.22± 0.03[bc]
	Adult	0	0	2	0
Deutonymph (lived for 28.56 h)	Egg	0.43± 0.11[a]	0	2	0.08± 0.02[a]
	Larva	1.26± 0.16[c]	0	3	0.25± 0.03[c]
	Protonymph	0.60± 0.12[ab]	0	2	0.12± 0.02[ab]
	Deutonymph	1.06± 0.13[bc]	0	3	0.21± 0.02[bc]
	Adult	0.03± 0.33[a]	0	1	0.00± 0.00[a]
Adult (in 24 h)	Egg	2.55± 0.27[bc]	1.5	4	0.51± 0.05[bc]
	Larva	3.05± 0.22[c]	1.5	4	0.61± 0.04[c]
	Protonymph	2.20± 0.26[abc]	1	3.5	0.44± 0.05[abc]
	Deutonymph	1.80± 0.22[ab]	0	2.5	0.36± 0.04[ab]
	Adult	1.20± 0.85[a]	0.5	3	0.24± 0.05[a]

*****For each feeding stage of the predator, values with the same alphabetical superscript within the column are not statistically significant @ P=0.01; ***Ne:** Number of prey stages consumed; **No**: Number of prey stages offered predatory mite *N. longispinosus* on prey mite, *T. macfarlanei*. The non-feeding behavior is not only confined to *N. longispinosus*, as larvae of *Euseius ovalis* on *T. macfarlanei* prey (Liyaudheen et al., 2014); *Phytoseiulus longipes* on *Tetranychus pacificus* (Badii et al., 1999) and *Typhlodromus pyri* on *Tetranychus urticae* (Croft and Croft, 1993) had been reported as non-feeding. Each protonymph of *N. longispinosus* consumed 0.40 eggs, 1.13 larvae, 0.76 protonymphs and 0.66 deutonymphs of *T. macfarlanei*, while no adult prey mites were consumed in its mean lifespan of 26.24 hr, indicating its preference for the larval stage with a mean consumption of 37% followed by nymphal stages with consumption rate of 25%, 22%. The deutonymph consumed 0.43 eggs, 1.26 larvae, 0.60 protonymphs, 1.06 deutonymphs and 0.03 *T. macfarlanei* adults in its lifespan of 28.56 hr, which indicated its preference for larva and deutonymphal stages of prey mite with a mean consumption rate of 25 and 21%, followed by protonymphs 12%, the egg and adult prey mite. The adult female consumed a mean of 2.55 prey eggs, 3.05 prey larvae, 2.20 protonymphs, 1.80 deutonymphs, and 1.20 adults over the course of a 24 hr period, showing preference for larval stage followed by eggs and nymphs. Hegde and Patil (1994), while studying the prey stage preference of the predatory mite, *Amblyseius longispinosus* (=*Neoseiulus longispinosus*) for *T. macfarlanei* prey (on cotton) reported that the predator exhibited its preference for prey eggs compared to other prey stages. The results are different from the present study results, where, the predatory mite exhibited preference for larval stage followed by eggs and nymphs in 24 hr window when prey stages were together but exhibited equal preference for both egg and larval stage in its entire lifespan when prey stages were offered individually.

Rahman et al. (2011) on the prey stage preference of *N. longispinosus* on the tea spider mite *Oligonychus coffeae* showed that the predatory mite preferred larval stages, followed by nymphs, eggs and adults. This supports the findings in the present study, wherein, *N. longispinosus* mostly preferred larva and egg stages. The adult female of *Euseius ovalis* predatory mite was identified as the most potent predator among all predator stages, and it preferred to feed on egg stages rather than other stages of *T. macfarlanei* (Liyaudheen, 2014). According to a study by Jyothis and Ramani (2022) the feeding preferences of adult *N. longispinosus* predator on *T. macfarlanei* declined from egg through nymph to larva. The present results are however in slight variation, and demonstrated that predator preference was more pronounced for both the prey mite's larval and egg stage in its entire lifespan. More preference towards the eggs and larval stages of spider mite by other phytoseiid predatory mites had been reported. Farazmand et al. (2012), while studying the functional response of the predatory mite *N. californicus* on *T. urticae* found that the predatory mite consumed more of eggs when choice was given between stages.

Daily prey consumption of lifestages of *T. macfarlanei* by adult female predatory mite, *N. longispinosus* over the course of its entire lifespan presented in Table 2 and the total prey consumption by lifestages of predatory mite on those of prey mite when prey mites were offered separately or together are given in (Table 3). Daily consumption on lifestages of prey mite by predatory mite indicated that in a single day one female predatory mite consumed a maximum of 9.5 eggs or 11.5 larvae or 6.7 nymphs or 1.8 prey adults when offered separately or 7.1 prey individuals, when offered together and per day mean consumption was 6.61 eggs or 7.33 larvae or 4.19 nymphs or 0.85 prey adults when offered separately or 4.98 mixed prey stages, when offered together. The longevity of female predatory mite when offered prey eggs or larvae or nymphs or adults separately, or together, ranged from 15-30, 19-27, 18-25, 17-28 and 19-26 days, respectively (Table 2). When prey was provided either separately or in combination, the predatory mite's larva did not eat any of the prey stages. The predator protonymph ingested 2.40 eggs, 3.40 larvae, 1.60 nymphs, or 0.20 adults. The deutonymph consumed a mean of 4.00 eggs or 4.70 larvae or 3.20 nymphs or 0.20 adults or 3.10 mixed prey stages. Alternatively, adult female predatory mite consumed a mean of 117.90 prey individuals as mixed stages, or 159.00 eggs, 171.60 larvae, 94.20 nymphs, or 19.20 adult prey mites when offered separately.

Consumption of prey eggs was observed to be less in the present study compared to the observations of Hegde and Patil (1994) on the feeding potential of the predatory mite *A. longispinosus* on cotton red spider mite *T. macfarlanei*; it was observed that the predator larvae were hardly feeding, while protonymph fed on an 3.2 eggs and 0.3 larva. Deutonymph fed 8.37 eggs, 0.88 larva, 0.71 nymphs and 0.55 prey adults/ day. The adult female consumed of 14.22 eggs, 2.41 larvae, 1.72 nymphs and l.05 prey adults. Jose et al. (1989) studied the ability of the predatory mite. *A. alstonia* to feed on the spider mite *T. Macfarlanei* on cotton and found that over the course of its lifetime, each *A. alsloniae* individual consumed on average of 191.30 eggs, 76

Table 2. Daily feeding potential of adult predatory mite *N. longispinosus* on lifestages of prey mite *T. macfarlanei*

Feeding period	Number consumed								
	When single prey stage offered				When all prey stages offered together				
	Egg	Larva	Nymph	Adult	Egg	Larva	Nymph	Adult	Total
Day 1	3.0 (10)*	3.0 (10)	0.7 (10)	0.0 (10)	0.3	0.1	0.0	0.0	0.4 (10)
Day 2	3.9 (10)	3.5 (10)	2.1 (10)	0.2 (10)	0.6	1.2	0.8	0.3	2.9 (10)
Day 3	5.5 (10)	5.4 (10)	3.3 (10)	1.2 (10)	1.3	2.3	0.8	0.0	4.4(10)
Day 4	8.3 (10)	7.1 (10)	4.3 (10)	0.9 (10)	2.3	2.0	1.5	0.8	6.6(10)
Day 5	8.0 (10)	8.5 (10)	5.0 (10)	0.8 (10)	1.4	2.6	1.7	1.2	6.9(10)
Day 6	8.5 (10)	8.8 (10)	5.3 (10)	0.5 (10)	1.8	2.6	1.3	1.4	7.1(10)
Day 7	7.9 (10)	9.9 (10)	6.2 (10)	1.1 (10)	1.3	2.1	1.9	1.3	6.6(10)
Day 8	9.5 (10)	10.6 (10)	6.7 (10)	1.4 (10)	0.8	2.9	1.6	0.2	5.5(10)
Day 9	7.8 (10)	10.3 (10)	6.6 (10)	1.3 (10)	1.4	2.8	1.0	0.4	5.6(10)
Day 10	7.9 (10)	10.2 (10)	6.3 (10)	1.2 (10)	1.6	2.5	1.2	0.2	5.5(10)
Day 11	8.2 (10)	10.7 (10)	6.3 (10)	1.6 (10)	2.0	2.8	1.7	0.5	7.0(10)
Day 12	8.0 (10)	11.0 (10)	5.0 (10)	1.8 (10)	1.7	2.3	1.3	0.6	5.9(10)
Day 13	6.0 (10)	11.5 (10)	5.7 (10)	1.1 (10)	2.1	2.6	0.9	1.0	6.6(10)
Day 14	6.3 (10)	11.2 (10)	5.6 (10)	0.9 (10)	2.7	2.7	1.3	0.4	7.1(10)
Day 15	6.6 (10)	10.0 (10)	4.3 (10)	1.2 (10)	2.7	1.9	0.9	0.5	6.0(10)
Day 16	9.6 (9)	8.6 (10)	4.9 (10)	0.8 (10)	2.5	2.0	0.9	0.6	6.0(10)
Day 17	9.1 (9)	8.9 (10)	3.7 (10)	0.4 (8)	2.0	2.1	0.9	0.3	5.3(10)
Day 18	7.8 (9)	6.0 (10)	3.7 (9)	0.6 (8)	2.5	2.5	1.2	0.1	6.3(10)
Day 19	7.8 (8)	6.4 (9)	5.4 (8)	0.6 (7)	2.4	2.3	0.8	0.6	6.2(9)
Day 20	8.3 (8)	4.9 (8)	5.3(7)	0.4 (7)	2.6	1.7	0.0	0.0	4.3(7)
Day 21	6.8 (7)	4.3 (6)	2.3 (6)	1.4 (5)	1.7	1.7	0.6	0.4	4.4(7)
Day 22	7.3 (6)	3.0 (6)	2.8 (4)	0.8 (5)	1.2	1.7	0.2	0.0	3.0(6)
Day 23	5.2 (6)	1.7(6)	0.5 (4)	1.3 (3)	1.2	0.5	0.5	0.3	2.5(6)
Day 24	3.3 (6)	1.0 (4)	0.3 (4)	1.0 (2)	0.8	0.3	0.0	0.0	1.2(6)
Day 25	3.3 (4)	0.0 (3)	0.0 (3)	0.0 (2)	0.7	0.7	0.0	0.0	1.3(3)
Day 26	2.3 (4)	0.0(3)	-	0.0 (2)	0.0	0.0	0.0	0.0	0.0(1)
Day 27	1.7 (3)	0.0 (1)	-	0.0 (2)	-	-	-	-	-
Day 28	2.5 (2)	-	-	0.0 (2)	-	-	-	-	-
Day 29	0.0 (1)	-	-	-	-	-	-	-	-
Day 30	0.0 (1)	-	-	-	-	-	-	-	-
Avg. per day consumption	6.61± 0.39[cd]	7.33± 0.33[d]	4.19± 0.23[b]	0.85± 0.17[a]	1.60± 0.15[b]	1.80± 0.17[b]	0.88 ± 0.11[a]	0.42± 0.82[a]	4.70± 0.28

*Figures in parentheses indicate number of female predatory mites alive from 10 individuals

larval, 2.60 nymphs and 46.24 adults of the prey mite *T. macfarlanei*. In contrast, in the current study, the predatory mite *N. longispinosus* devoured 99 nymphs, 19 adults, 165.40 eggs and 179.70 larval. Manjunatha et al. (1995) reported that the adult predatory mite consumed 14.22 eggs, 2.4 larvae, 1.72 nymphs and 1.05 adult prey mites of *T. macfarlanei* in 24 hr which is lower compared to the present results (6.62 eggs, 7.33 larvae, 4.19 nymphs, 0.85 adults). Ali et al. (2011) found that the predatory mite *Neoseiulus womersleyi* consumed 62.25 eggs, 69.87 larvae, 31.87 protonymphs and 23.81 deutonymphs of *T. macfarlanei*; and larvae were the most consumed prey stage, followed by eggs, protonymphs and deutonymphs. In the present study the *N. longispinosus* stages was found consuming more larvae numerically followed by other stages

Table 3. Feeding potential of lifestages of predatory mite *N. longispinosus* on lifestages of prey mite *T. macfarlanei*

Feeding stages of predatory mite	Number consumed (Mean± S.E.)							
	Single prey stage offered				Prey stages offered together			
	Egg	Larva	Nymph	Adult	Egg	Larva	Nymph	Adult
Protonymph	2.40± 0.22^{bc*}	3.40± 0.22^{c}	1.60± 0.42^{ab}	0.20± 0.13^{a}	0.40± 0.22^{a}	1.10± 0.17^{a}	0.70± 0.15^{a}	0
Deutonymph	4.00± 0.42^{bc}	4.70± 0.26^{c}	3.20± 0.13^{b}	0.20± 0.20^{a}	1.30± 0.26^{b}	1.30± 0.21^{b}	0.40± 0.22^{ab}	0.10± 0.10^{b}
Adult (life period)	159.00± 17.79^{cd}	171.60± 11.47^{d}	94.20± 6.01^{b}	19.20± 4.21^{a}	38.50± 1.66^{c}	46.20± 1.92^{c}	22.40± 2.48^{b}	10.80± 1.54^{a}
Total	165.40± 17.90^{cd}	179.70± 11.48^{d}	99.00± 5.90^{b}	19.60± 4.20^{a}	40.20± 1.76^{c}	48.60± 1.85^{c}	23.50± 2.41^{b}	10.90± 50^{a}

*Mean values superscripted by the letter within the row are not significantly different @ p=0.01

of *T. macfarlanei*. Thus it could be concluded that active stages of *N. longispinosus* efficiently consumed all developmental stages of *T. macfarlanei* with a preference for egg and larval stage and can be used as an effective biocontrol agent against *T. macfarlanei* as an ecofriendly IPM approach.

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AUTHOR CONTRIBUTION STATEMENT

Carried out experiment, data collection and manuscript preparation (NN); Planned and designed experiment and reviewed the manuscript (CCG, NS and NS).

CONFLICT OF INTEREST

No conflict of interest.

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