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Feeding Biology of *Euseius pariyarensis* (Santhosh, 2018) (Acari: *Phytoseiidae*) on Red Spider Mite *Tetranychus neocaledonicus* (Andre, 1933) Infesting *Bauhinia acuminate* L.

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Euseius pariyarensis (Santhosh, 2018) is a predatory mite, found associated with the pest mite, *Tetranychus neocaledonicus* (Andre, 1933) which infest the leaves of *Bauhinia acuminate* L. To study the feeding potential, tests were carried out in the laboratory under 30±2°C, 65±10%RH conditions. Promising results were obtained and the following observations were made regarding its feeding activities. Maximum consumption of eggs of prey mite was exhibited by adult females. The mean consumption rate of predators followed the order that female > male > deutonymph > protonymph >larva, respectively.

Keywords: Predatory mite; Phytoseiidae; feeding potential.

1. INTRODUCTION

Predatory mites of the family *Phytoseiidae* are excellent agents for biological control programs [1].Phytoseiids are the best known and most studied group of predatory mites, owing to their success in controlling spider mites as well the eggs and life stages of other small insect pests. Pappas et al., [2], Abdallah et al. [3] and Gilliat [4] studied the feeding potential of phytoseiid mites in regulating pest populations under both laboratory and field condition. Studies conducted by Chant [5] and, Mc Murtry and Scriven [6] reported that alternate food increased the intensity of predation as well as the density of the predators. Biological and ecological studies on phytoseiids have shown that they are very effective for controlling several pests of agricultural importance. In Kerala, a predatory mite, *Euseius pariyarensis,* was reported from the medicinal plant, *Bauhinia acuminate* L., as a biological control agent of red spider mites [7]. Many species of phytoseiid mites are good biological control agents of injurious plant feeding mites in the families Tetranychidae, Tenuipalpidae, Eriophyidae, as well as others [8]. Though phytoseiids are normally known to feed and develop on phytophagous mites and small insect pests, many can survive on non prey food materials like honey, nectar, plant sap and pollen [9]. Phytoseiids utilise different types of food and these specializations are correlated with major ecological traits such as aggregating ability and prey density dependence [10].

Phytoseiids shows several advantages over other predatory mites because of their high fecundity, good searching ability, dispersal rate, adaptability and high degree of prey specificity. Many phytoseiids develop quickly, within one week at 27^{0}C and 60-90% RH [11,12]. Some successful phytoseiid such as *Phytoseiulus, Neoseiulus, Euseius, Typhlodromus, Typhlodromalus, Amblyseius*etc. are excellent biocontrol agents show functional responses to their prey [13]. Many species are commercially available for pest control purposes and are especially useful in green house farming. The commercially available predatory mite *Phytoseiulus persimilis* is quick-acting. Badii et al. [14] studied the prey stage preference and functional response of *Euseius hibisci* to *T. urticae* on strawberry leaf arenas under laboratory conditions of 25 ± 2°C, 60 ± 5% RH and 12 h photophase. They reported that the predator consumed significantly more prey eggs than other prey stages and consumption of prey deutonymphs and adults was so low.

2. MATERIALS AND METHODS

During the present study *Tetranychus neocaledonicus* infesting the plant *Bauhinia acuminate* were selected as prey food for studying the feeding preferences of the phytoseiid mite, *Euseius pariyarensis.* This spider mite is recognized as a widely distributed pest on *B. acuminata* in most of the localities surveyed. Infestation by this mite results in the formation of white spots on the leaf lamina due to chlorosis. Infestations led to bronzing and blotching of leaves followed by premature leaf fall.

2.1 Raising Stock Cultures of *T. neocaledonicus* in the Laboratory

Seedlings of *B. acuminata* were planted in pots of 1x1x1 m^3 kept in the herbal garden of Malabar Christian College, Calicut for artificial infestation with *T. neocaledonicus.* Mite infested leaves were collected from different localities and brought to the laboratory. Adults were picked up with a moistened camel hair brush using a hand lens and transferred to the newly planted *B.*

acuminata plant seedling when new leaves began to sprout.

2.2 Raising of Stock Cultures of the Predatory mite *E. pariyarensis* in Laboratory

Different stages of the predatory mite *E. pariyarensis* were also collected from *Bauhinia* plants infested with the prey mite, *T. neocaledonicus.* Predatory mites were carefully transferred from the leaves to the culture cell. Different stages of the prey mite, in sufficient numbers were offered as food for rearing the predatory mites. For these, sufficient stock cultures of *E. pariyarensis* were build up in the laboratory using leaf floatation technique [15]. When depletion of prey mites was noticed, new mites were brushed from the infested *Bauhinia* leaves, which were maintained in the garden. To start with the feeding efficacy test numerous replicates of such culture cells were prepared.

2.3 Feeding Preference

For studying the feeding preference of the individual stages of predatory mites to various stages of prey mites different culture cells were maintained in the laboratory. For this, separate culture cells containing different life stages of *T. neocaledonicus* were prepared and different stages of predatory mite larvae, protonymphs, deutonymphs, adult males and females were released to each culture cell for recording observation on feeding preference of the particular life stages. There were 5 experimental setups for each stage of the prey *i.e,* set I- prey eggs Vs adult female predator, set II-prey eggs Vs adult male predator, set III- prey eggs Vs deutonymph, set IV- prey eggs Vs protonymph and set V- prey eggs Vs larva. Similarly, different stages of prey mites were also kept in separate culture cells and different stages of predators were released to each cell, separately. For this, 25 of each of the life stage of the prey mite was also kept in separate culture cell exposed to a single number of different stages of the predators *i.e.,* larva, protonymph, deutonymph, adult male and female. Observations were taken on the feeding behavior of the various stages of predators, the mode of feeding of individual stages and the feeding potential of the predators on various stages of the prey mites were taken on a 24 hour basis.

Data obtained on the above parameters were recorded, tabulated, and presented through appropriate figures and graphs. Data obtained on feeding preference were subjected to statistical analysis based on a Scheffe test and ANOVA and presented.

3. RESULTS AND DISCUSSION

A. Feeding behaviour of *E. pariyarensis*

The feeding activities of all stages of *E. pariyarensis* were of similar pattern from the larval stage onwards. All the life stages, other than the larval, were seen actively moving about on the under surface of leaves in search of prey. The web found on the ribs of the leaves hinders the fast movement of predators.

As a predator came into touch with prey, it was observed slowly grabbing the prey with the aid of its lengthy forelegs and palps. While firmly holding the body of the prey with its forelegs, the predator extends its chelicera to paralyse the prey. With the help of its strongly built chelicera, a predator penetrated the cuticle of the prey and initiated feeding upon internal tissue contents. During the feeding process, the muscular and pharyngeal movements of the predator were clearly noticeable under high power magnification. Based on the colour of prey mites consumed, the body colour was found to chan ge and the fully fed predatory mite resembled the colour of the prey mite.

The average time taken by various stages of the predatory mite to consume different stages of the prey mite were noted and feeding time varied with respect to life stage of the predator as well prey mite. Adult male predators took approximately 5 minutes to remove the internal contents of prey mite eggs, whereas females took 5 -10 minutes. The eggs of the prey were found rolled by the combined action of chelicerae and pedipalp at the time of feeding. Adult female predator mites required 20-25 minutes to completely remove the internal contents of the various stages of the pest mites. Prey eggs were the most preferred food for all stages of the predator. Liyaudheen et al. [16] conducted a study on feeding potential of *E. ovalis* on *T. macfarlanei* infesting Okra plants and reported feeding preference on the eggs of the pest mite followed by the larva and protonymph. Adult females consumed more eggs than other stages after mating. The average consumption time taken by different stages of the predator increased with progressive development of the prey.

There were also some instances where the predator did not complete feeding before moving to the next prey. Quiescent stages of prey mites were also preferred for feeding. When prey density was high, random attack was evident and rate of predation was comparatively high. The feeding potential of individual stages of predatory mites varied considerably. The average time taken for the consumption of prey mites varied with respect to the size of the body.

B. Consumption rate of *E. pariyarensis*

The consumption rate of every stage of the predator was noted after a time period of 24 hours and the results were statistically analysed. Predator larva did not feed on larvae, protonymphs, deutonymphs, and adult stages of the prey mite *T. neocalidonicus* (Table 1).

The average rates of food consumed by different stages of *E. pariyarensis* were calculated and the percentage of predation was noted (Table 1 & Fig. 1). Sixty one percentage of the eggs of the prey mite were consumed by the female, 21% by the deutonymph, 12% by the protonymph, followed by the larva (1%). Adult females consumed a higher percentage of larvae of prey mites (21%) followed by the male and deutonymph (4%). Adults of the prey mites consumed by the predator adult females and males were only 2% and 1%, respectively, but this value is greater when compared to the rate consumed by other predator stages. Males of the predator mite showed a high predation percentage on the eggs (42%), larvae (16%), protonymphs (6%) and deutonymphs (2%). Deutonymphs also exhibited significant predation on various prey stages *i.e.,* eggs (21%), larvae (4%), and protonymph (1%). Larvae fed only on prey mite eggs (1%). Even though the rate of predation varies for each stage of prey, maximum predation in all cases was shown by adult female *E. pariyarensis* (Table 1).

The results obtained were subjected to ANOVA for testing the significance and comparison was made using Scheffe's test. The results indicated a p-value less than 0.01 and 0.05, which shows high significance.

Table 1. Percentage of predation of *E. pariyarensis* on various stages of *T. neocalidonicus* in24hours

Prey / Predator	Egg	Larva	Protonymph	Deutonymph	Adult
Female	61	21	8	3	2
Male	42	16	6	2	0
Larva	1	0	0	0	0
Protonymph	12	0	0	0	0
Deutonymph	21	4	1	0	0

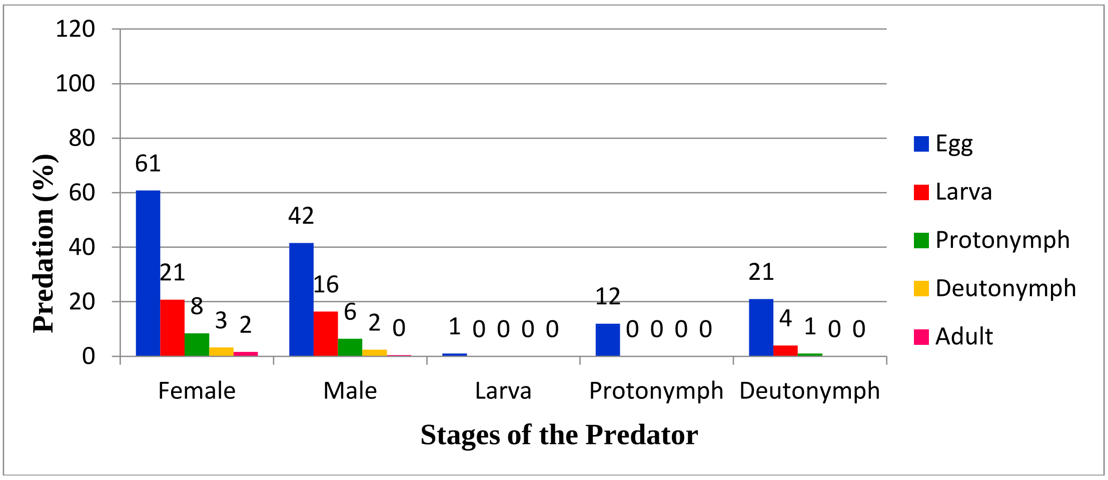

Fig. 1. Percentage of consumption of *E. pariyarensis* on various stages *T.neocalidonicus* in 24 hours

Table 2. Representing Feeding potential of *E. pariyarensis* on *T. neocalidonicus*

Prey / Predator	Egg	Larva	Protonymph	Deutonymph	Adult
Female	15.2±1.30	5.2±0.61	2.1±0.18	0.8±0.20	0.4±0.16
Male	10.4±1.37	4.1±0.41	1.6±0.34	0.6±0.16	0.1±0.1
Deutonymph	5.3±0.60	1.0±0.67	0.2±0.13	0±0	0±0
Protonymph	2.9±0.23	0.1±0.10	0±0	0±0	0±0
Larva	0.3±0.15	0±0	0±0	0±0	0±0

While comparing the mean values of the feeding potential of the different stages *E. pariyarensis i.e.,* larva, protonymph ,deutonymph and adults, on the prey egg stage, it was noted to have a high significant difference at 0.01 level (P <0.01) (Tables 3 & 4). There were significant differences noted on the feeding of prey eggs between different life stages of *E. pariyarensis* except between larva and protonymph and between protonymph and Deutonymph (Tables 3 & 4). Abou-Setta and Childers [17] studied the feeding behaviour and oviposition of *E. mesembrinus* under 26^{0}C and 75 % RH and found that all motile stages of tetranychid mites were attacked, except the adult. A significant difference was noted on the feeding of prey larva by the predator, except female and male, larva and protonymph, larva and deutonymph, and protonymph and deutonymph (Tables 3 & 4, Fig. 2). Abad-Movano (2009).

Table 3. Mean values of feeding potential of different stages of the predator *E. pariyarensis* against different life stages of the prey, *T. neocalidonicus*

		Prey Egg				
Predator	**N**	**Mean**	**SD**	**SE**	**F**	**p-value**
Female	10	15.20	4.131	1.306		
Male	10	10.40	4.326	1.368		
Larva	10	0.30	0.483	0.153	44.62	.000
Protonymph	10	2.9	0.738	0.233		
Deutonymph	10	5.3	1.888	0.597		
		Prey Larva				
Predator	**N**	**Mean**	**SD**	**SE**	**F**	**p-value**
Female	10	5.20	1.932	0.611		
Male	10	4.10	1.287	0.407		
Larva	10	0.0	0.0	0.0	48.935	.000
Protonymph	10	0.10	0.316	0.100		
Deutonymph	10	1.00	0.667	0.211		
		Prey Protonymph				
Predator	**N**	**Mean**	**SD**	**SE**	**F**	**p-value**
Female	10	2.10	0.568	0.180		
Male	10	1.60	1.075	0.340		
Larva	10	0.00	0.000	0.000	21.160	.000
Protonymph	10	0.00	0.000	0.000		
Deutonymph	10	0.20	0.422	0.133		
		Prey Deutonymph				
Predator	**N**	**Mean**	**SD**	**SE**	**F**	**p-value**
Female	10	0.80	0.632	0.200		
Male	10	0.60	0.516	0.163		
Larva	10	0.00	0.000	0.000	11.400	.000
Protonymph	10	0.00	0.000	0.000		
Deutonymph	10	0.00	0.000	0.000		
		Prey Adult				
Predator	**N**	**Mean**	**SD**	**SE**	**F**	**p-value**
Female	10	0.40	0.516	0.163		
Male	10	0.10	0.316	0.100		
Larva	10	0.00	0.000	0.000	4.091	.007
Protonymph	10	0.00	0.000	0.000		
Deutonymph	10	0.00	0.000	0.000		

Table 3 shows the mean values for the number of stages of prey mite, *T. neocaledonicus,* consumed by *E. pariyarensis* in 24 hours. Maximum consumption of eggs of the prey mite was exhibited by adult females. The mean consumption rate of predators followed the order: female > male > deutonymph > protonymph >larva, respectively [18].

A significant difference was noted at the 0.01 level when comparing mean values of the prey protonymph stage by the different predators except the female and male, larva and protonymph, larva and deutonymph, and protonymph and deutonymph (Tables 3 & 4). Cruz-Miralles et al. [19] demonstrated that generalist predator activity of *Euseius stipulatus* which does better on *Tetranychus* in citrus plants. In the case of feeding on prey, the deutonymph showed significant differences except female and male, larva and protonymph, larva and deutonymph, and protonymph and deutonymph (Tables 3 & 4). On comparing the mean values of the feeding potential of different life stages of *E. pariyarensis* on adult prey mites, there were significant differences between predator stages, female and larva, female and protonymph, and female and deutonymph. All other stages were not significant (Tables 3 & 4). Nguyen and Shih [20] conducted a study on predation rates of *N. womersleyi* and *E. ovalis* feeding on tetranychid mites and found that the predation rate of *N.womersleyi* was higher than *E. ovalis* and they recommended that *T. urticae* eggs are suitable for mass rearing for both predatory mites.

Table 4. Significant combinations of the different stages of the predator, *E.pariyarensis,* against different life stages of the prey, *T.neocalidonicus,* using Scheffe's Test

			Prey Egg		
	Female	**Male**	**Larva**	**Protonymph**	**Deutonymph**
Female		.013*	.000**	.000**	.000**
Male			.000**	.000**	.007**
Larva				.391	.000**
Protonymph					.474
Deutonymph					
			Prey Larva		
	Female	**Male**	**Larva**	**Protonymph**	**Deutonymph**
Female		..294	.000**	.000**	.000**
Male			.000**	.000**	.000**
Larva				1.000	.391
Protonymph					.499
Deutonymph					
			Prey Protonymph		
Female		**Male**	**Larva**	**Protonymph**	**Deutonymph**
Female		.448	.000**	.000**	.000**
Male			.000**	.000**	.000**
Larva				1.000	.962
Protonymph					.962
Deutonymph					
			Prey Deutonymph		
Female		**Male**	**Larva**	**Protonymph**	**Deutonymph**
Female		.825	.001**	.001**	.001**
Male			.017*	.017*	.017*
Larva				1.000	1.000
Protonymph					1.000
Deutonymph					
			Prey Adult		
Female		**Male**	**Larva**	**Protonymph**	**Deutonymph**
Female		0.208	0.041*	0.041*	0.041*
Male			0.952	0.952	0.952
Larva				1.000	1.000
Protonymph					1.000
Deutonymph					

Significancelevelat≤0.05 Significancelevelat≤0.01*

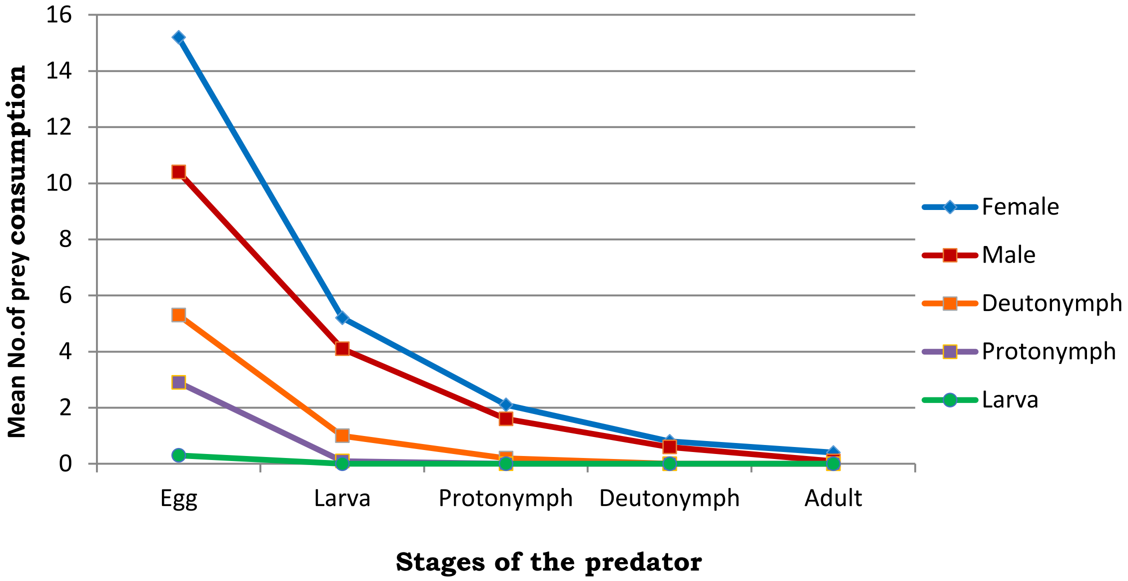

Fig. 2. Comparison of prey consumption of different stages of *E. pariyarensis* on various stages of *T. neocalidonicus*

4. CONCLUSION

Phytoseiid mites are considered the most efficient natural enemies for biological control of pest mites, especially those belonging to the family Tetranychidae, but this has not acquired recognition so far India, particularly in Kerala. Several acarologist from outside of India have contributed to the biological control aspects of predatory mites [1] and a few such works have also been done in India [21]. All of these studies emphasize the potential value of phytoseiids as biocontrol agents [17]. In the present study, an attempt to expose the feeding biology of a new species of predatory mite *Euseius pariyarensis* preying upon various stages of pest mite, *T. neocaledonicus* infesting the medicinal plant, *Bauhinia acuminate* was made*.* Through mass rearing, these predators can be use as biological control agents at a commercial scale for controlling insect pests on a variety of crops.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Knapp M, van Houten Y, van Baal E, Groot T. Use of predatory mites in commercial biocontrol: current status and future prospects. Acarologia. 2018;58(Suppl):72-82.
2. Pappas ML, Xanthis C, Samaras K, Koveos DS, Broufas GD.SKoveos.2013. Potential of the predatory mite Phytoseius finitimus (Acari: Phytoseiidae) to feed and reproduce on greenhouse pests. Exp Appl Acarol. 2013;61(4):387-401.
3. Abdalla AA, Zhang ZQ, Masters GJ, Mcneill S. Euseius Finlandicus. Exp Appl Acarol. 2001;25(10-11):833-47.
4. Gilliat FC. Some Predators of the European red mite, *Paratetranychus pilosus* C. and F in Nova Scotia. Can J Res. 1935;13:19-38.
5. Chant DA. An experiment in biological control of *Tetranychustelarius* (L.) (Acarina: Tetranychidae) in a greenhouse using the predaceous mite *Phytoseiulus*

persimilis Athias-Henriot (*Phytoseiidae*). Can Entomol. 1961;93(6):437-43.

6. McMurtry JA, Scriven GT. The influence of pollen and prey density on the number of prey consumed by *Amblyseius hibisci* (Chant) (Acarina: Phytoseiidae). Ann Entomol Soc Am. 1966;59(1):147-49.
7. Santhosh PP, Sadanandan MA, Rahul MP. Two new species of phytoseid mites Euseius (Acari:*Phytoseiidae*) from Kerala, India. 2018;10(13):12828-32.
8. Pijnakker J, Hürriyet A, Petit C, Vangansbeke D, Duarte MVA, Arijs Y et al. Evaluation of phytoseiid and Iolinid mites for BiologicalControl of the tomato russet mite Aculops lycopersici(acari: Eriophyidae). Insects. 2022;13(12):1146.
9. Marques RV, Sarmento RA, Ferreira VA, Venzon M, Lemos F, Pedro-Neto M et al. Aand A. Rev Colomb Entomol. Alternative food sources to predatory mites (Acari) in a *Jatropha curcas* (Euphorbiaceae) Crop. 2014;1:40.
10. Zhang N, Smith CL, Yin Z. Yan, Y and Lixia, X. Exp Appl Acarol. Effect of temperature on the adults and progeny of the predaceous mite *Lasioseius japonicas* (Acari: Blattisociidae) fed on the cereal mite *Tyrophagus puttrescentiae* (Acari: Acaridae). 2022;86:499-515.
11. Tanigoshi LK. Advances in knowledge of the biology of *Phytoseiidae*. In: Hoy MA, editor. Recent advances in knowledge other *Phytoseiidae*. University of California Publication. 3284. 1982;122.
12. Zhang ZQ, Croft BA. A comparative life history study of immature *Amblyseius fallacis*, *Amblyseius andersoni*, *Typhlodromus occidentalis*, and *Typhlodromus pyri* (Acari:*Phytoseiidae*) with a review of larval feeding patterns in the family. Exp Appl Acarol. 1994;18:631-57.
13. Kalile MO, Cardoso AC, Pallini A, Fonseca MM, Elliot SL, Fialho VS et al. A predatory mite as potential biological control agent of Diaphorina citri. Bio Control. 2021;66(2): 237-48.
14. Badii MH, Hernández-Ortiz E, Flores AE, Landeros JN. Prey stage preference and functional response of *Euseius hibisci* to *Tetranychusurticae* (Acari: *Phytoseiidae*). Exp Appl Acarol. 2004;34(3-4): 263-73.
15. Brodeur J, Cloutier C. A modified leaf disk method for rearing predaceous mites [Acarina:*Phytoseiidae*]. Phytoprotection. 1992;73(2):69-72.
16. Liyaudheen CKM, Rekha PK, Anitha K, Ramani N. Feeding potential of *Euseius ovalis*(Evans) (Acar idae: *Phytoseiidae*) on *Tetranychus macfarlanei* Baker and Pritchard (Acar idae: Tetranychidae) infesting okra. J Biopest. 2014;7;Suppl: 148-51.
17. Abou-Setta MM, Childers CC. Biology of *Euseius mesembrinus* (Acari: *Phytoseiidae*): Life tables and feeding behavior on tetranychid mites on citrus. Environ Entomol. 1989;18(4):665-9.
18. Binoy C, Sadanandan MA. Feeding biology of predatory mite *Euseius alstoniae* (Gupta, 1975) (Family: *Phytoseiidae*) on Red Spider Mite *Tetranychus neocaledonicus* (André, 1933) infesting *Moringa oleifera* Lam. Uttar Pradesh J Zool. 2015;35(2):147-50.
19. Cruz-Miralles J, Cabedo-López M, Guzzo M, Ibáñez-Gual V, Flors V, Jaques JA. Plant-feeding may explain why the generalist predator *Euseius stipulatus* does better on less defended citrus plants but Tetranychus-specialists *Neoseiulus* californicus and *Phytoseiulus persimilis* do not. Exp Appl Acarol. 2021;83(2): 167-82.
20. Nguyen TV, Shih CT. Predation rates of *Neoseiulus womersleyi* (Schicha) and *Euseius ovalis* (Evans) feeding on tetranychid mites (Acari: *Phytoseiidae*, Tetranychidae). J Asia Pac Entomol. 2011; 14(4):441-7.
21. Gupta SK. A monograph on plant inhabiting predatory mites in India. Part II: Order: Mesostigmata. Mem Zool Surv India. 2003;20(1):185.