Indian J. Appl. Ent. **32**(1) : 4–15 (2018)

INTERACTION BETWEEN PREDATORY MITE, *AMBLYSEIUS FINLANDICUS* (OUDEMANS) (ACARI: PHYTOSEIIDAE) AND SORGHUM MITE, *OLIGONYCHUS INDICUS* (HIRST)

SANCHIT MANDAPE, ABHISHEK SHUKLA AND G.G. RADADIA
Department of Entomology, N.M. College of Agriculture, Navsari Agricultural University, Navsari-396450, Gujarat, India

ABSTRACT

An experiment was carried out under polyhouse to investigate the interaction between the predatory mite, *A. finlandicus* and the prey, *O. indicus*. It was found that at 1:10 ratio, *A. finlandicus* caused maximum reduction of *O. indicus*. The predatory mite preferred to feed more upon eggs as compared to other mobile stages. It was also found that once the population of the prey *O. indicus* was reduced, the population of predatory mite also declined showing a density dependent activity.

Keywords: Interaction, sorghum mite, *Oligonychus indicus* (Hirst), predatory mite, *Amblyseius finlandicus* (Oudemans)

INTRODUCTION

The predatory mite, *Amblyseius finlandicus* (Oudemans) is widely distributed and has been recorded in many countries throughout Europe, Asia, and North America (Kropczynska and Tuovinen, 1988; McMurtry and Croft, 1997). It has been found on *Prunus* sp., *Pyrus* sp., and *Juglans* sp., forest and orchard trees (Ragusa-Di Chiara *et al*., 1995, Chillar *et al.,*2007). *A. finlandicus* is a typical mesostigmatic mite and its life cycle comprised an egg, three active immature stages (larva, protonymph, and deutonymph) and adult (Neelam Kumari, 1981). Its potential feeding on prey has been rarely addressed (Cox *et al*., 2006). Certain characteristics of Phytoseiidae mites may render them promising biological control agents for both conservation and augmentative biological control. They bear all advantageous traits of generalist predatory mites *i.e.* they survive and reproduce on a variety of mites as well as insects and also on alternative food sources, such as pollen and honey (McMurtry and Croft, 1997, Mandape and Shukla, 2017). The ability of a generalist predator like phytoseiids to feed on more than one pest could prove beneficial for the outcome of biological control through the increase in its densities, as well as the positive effects of mixed diets on the predator's performance (Messelink *et al*., 2008, 2010, 2013; Momen and El-Borolossy, 2010). So far, very little information is available on the feeding potential of the predatory mite like *A. finlandicus* on different species of phytophagous mites. Therefore, the present paper reports the feeding potential of phytoseiid predator *A. finlandicus* as bio-control agents of some most important plant mites under laboratory conditions.

MATERIAL AND METHODS

The present study was on interaction between predatory mite, *A. finlandicus* and its prey *O. indicus*. The details of the experiment were as follows:

Nucleus culture of phytoseiid mite, *A. finlandicus*: The field collected adults of predatory mite, *A. finlandicus* were brought to the laboratory and these adults were sexed and released in pairs on french bean leaves already infested by *T. urticae*. After 48 hours, the eggs laid by the pairs were collected and placed separately and reared on french bean leaves already infested by *T. urticae.* The adults thus obtained were released and placed for mating and the next progeny obtained from this culture was used for further experimental studies.

Laboratory culture of prey mite *O. indicus*: The laboratory culture of sorghum mite was maintained on sorghum leaves and on potted plants of sorghum in Polycarbonate house of Department of Entomology, Navsari Agricultural University, Navsari. The laboratory culture of *O. indicus* was maintained on leaf bits of sorghum (2 cm^2). A gravid female of sorghum mite was released on this leaf bit for 24 hours for egg laying. The female was removed after 24 hours and the eggs thus laid by these females were used for the further multiplication and experiments.

Interaction between *A. finlandicus* and *O. indicus*: The interactions between predator and prey were carried out under polyhouse condition on sorghum

following predator- prey ratio of 1: 10, 1: 20, 1: 30 and 1: 50 along with predator free plants (Control). First the gravid female of prey was released on upper leaf region of sorghum 10-12 days prior to the release of predator so that sufficient numbers of prey were present on the leaf before the release of predator. The gravid female of *A. finlandicus* then was released on the upper leaf of sorghum. The predatory mites were released on top leaves of sorghum as per the ratios mentioned above. Three leaves from each plant were sampled and observations on predator and prey mites were recorded before the release and 4, 8, 12, 16, 20, 24, 28, and 32 days after release. The leaf samples were collected in separate polythene bags and brought to the Acarology laboratory and the observations on eggs, nymphs and adult stages of both prey and predators were recorded.

RESULTS AND DISCUSSION

The interaction between predator and prey mite was presented under the following headings:

Eggs: During the year 2014-15, before release of gravid females of *A. finlandicus* the number of eggs of *O. indicus* were 139.67 per leaf at ratio 1:10, but on 28 DAR the predator consumed all of the eggs of *O. indicus* (Table 1). The prey elimination was also observed at 1:20 ratio at 32 DAR. At the ratio of 1:30, 1:40 and 1:50 the initial number of eggs were 140.00, 138.33 and 140.33 per leaf, respectively which were reduced to 3.67, 19.00 and 26.67 per leaf, respectively on 32 DAR. In the year 2015-16 the initial number of eggs of *O. indicus* at predator : prey ratio 1:10 was 141.00 mites per leaf which was reduced to zero on 28 DAR. In case of predator : prey ratio 1:20 also the number of eggs reached to zero at 32 DAR. At the ratios 1:30, 1:40 and 1:50 the initial number of eggs was 141.33, 141.33 and 141.33 per leaf, respectively which was gradually reduced to 3.00, 16.67 and 22.33 per leaf, respectively. The pooled analysis over two years revealed that interaction (Y x T) between year of observation (Y) and treatment (T) was found to be non significant exhibiting similar response of the predator to prey over the years (Table 2). At ratio of 1:10 the initial number of *O. indicus* eggs before release of gravid females of *A. finlandicus* was 140.33 per leaf which reached to zero on 28 DAR while at 1:20 ratio it reached to zero at 32 DAR. At 1:30, 1:40 and 1:50 ratios initial number of eggs were 140.67, 139.83 and 140.83 per leaf, respectively, that were gradually reduced to 3.33, 17.83 and 24.50 per leaf, respectively at 32 DAR.

Nymphs: In case of nymphs during the year 2014-15, the nymphal population of *O. indicus* before release of predator, *A. finlandicus* at the ratio 1:10 was 39.67 per leaf (Table 3). The prey elimination was noticed at 24 DAR, at the ratio of 1:20 the prey elimination was recorded at 28 DAR and at 1:30 ratio it was noticed at 32 DAR. At 1:40 and 1:50 ratios the population of nymphs before release of the gravid females of *A. finlandicus* was 39.33 and 39.67 per leaf, respectively. It was gradually reduced at different time intervals and reached to 5.67 and 11.00 per leaf, respectively at 32 DAR. Similarly, in the next year 2015-16, the initial population of *O. indicus* nymphs at 1:10 ratio was 32.00 and the prey elimination was observed at 24 DAR, while at 1:20 and 1:30 ratio the prey was completely eliminated at 28 and 32 DAR, respectively. At 1:40 and 1:50 ratios the initial population on *O. indicus* nymphs was 37.67 and 39.67 per leaf, respectively and was reduced that reached to 3.33 and 10.00 per leaf, respectively at 32 DAR. The pooled data revealed that interaction (Y x T) was found non significant exhibiting similar response of predator to prey population over years (Table 4). Initial population of *O. indicus* nymphs at 1:10 ratio was 38.83 per leaf which gradually decreased at different time interval and prey was completely eliminated at 24 DAR whereas, at 1:20 and 1:30 ratios the prey was completely eliminated at 28 and 32 DAR, respectively. At 1:40 and 1:50 ratios the initial population was 38.50 and 39.67 per leaf, respectively which was reduced to 4.50 and 10.50 per leaf, respectively at 32 DAR.

Adult: During the year 2014-15 the population of adult sorghum mite, *O. indicus* at 1:10 ratio was 28.25 per leaf before release of *A. finlandicus* and the prey population was completely eliminated at 32 DAR; while, during the year 2015-16, the initial population was 27.33 per leaf at 1:10 ratio during this year also the prey was completely eliminated at 32 DAR (Table 5). The initial population of adult *O. indicus* at 1:20, 1:30, 1:40 and 1:50 ratios during the year 2014-15 were 29.33, 29.33, 29.67 and 29.67 per leaf, respectively which was reduced and reached to the level of 6.00, 11.33, 16.67 and 21.33 adults per leaf, respectively at 32 DAR; while in the year 2015-16 the initial population of adult *O. indicus* at 1:20, 1:30, 1:40 and 1:50 ratios was 30.33, 31.00, 30.67 and 30.33 per leaf, respectively, which was reduced to 3.67, 8.67, 11.67 and 16.67 per leaf, respectively at 32 DAR. The pooled data revealed that interaction (Y x T) was found non significant, exhibiting similar response of predator to prey population over years (Table 6). At 1:10 predator : prey ratio the population of *O. indicus*adults was 29.17 per leaf before introduction of gravid females of *A. finlandicus* on sorghum plant the population where prey was completely eliminated at 32 DAR. The initial population of adult prey at 1:20, 1:30, 1:40 and 1:50 ratios was 29.83, 30.17, 30.17 and 30.00 per leaf, respectively, which reached to 4.83, 10.00, 14.17 and 19.00 per leaf, respectively at 32 DAR.

Total population: During the year 2014-15, the total population (eggs + nymphs + adults) of sorghum mite, *O.*

Table 1. Interaction of *A. finlandicus* with *O. indicus* (Eggs)

Ratio	2014-15									2015-16								
	Pre treatment	4 DAR	8 DAR	12 DAR	16 DAR	20 DAR	24 DAR	28 DAR	32 DAR	Pre treatment	4 DAR	8 DAR	12 DAR	16 DAR	20 DAR	24 DAR	28 DAR	32 DAR
1:10	139.67 (11.74)	122.67 (11.08)	75.00 (8.74)	46.67 (6.91)	25.67 (5.29)	15.00 (3.95)	3.33 (1.82)	0.00 (0.70)	0.00 (0.71)	141.00 (11.86)	122.33 (11.11)	78.67 (8.76)	52.33 (7.24)	34.00 (5.80)	18.00 (4.25)	4.33 (1.95)	0.00 (0.71)	0.00 (0.71)
1:20	138.00 (11.75)	127.00 (11.20)	94.00 (9.71)	63.33 (8.04)	50.33 (7.21)	34.67 (5.97)	14.67 (3.77)	4.67 (2.20)	0.00 (0.71)	141.33 (11.87)	131.00 (11.45)	94.33 (9.69)	75.00 (8.56)	57.00 (7.48)	31.33 (5.78)	12.00 (3.43)	3.67 (2.11)	0.00 (0.71)
1:30	140.00 (11.85)	130.33 (11.49)	119.67 (10.92)	107.67 (10.37)	83.33 (9.19)	51.67 (7.31)	25.33 (5.04)	13.67 (3.83)	3.67 (2.00)	141.33 (11.90)	136.33 (11.68)	125.00 (11.21)	108.67 (10.38)	88.00 (9.43)	54.67 (7.47)	26.00 (5.12)	16.33 (4.06)	3.00 (1.94)
1:40	138.33 (11.75)	133.00 (11.54)	128.00 (11.28)	117.33 (10.86)	91.67 (9.62)	72.67 (8.57)	38.33 (6.26)	26.67 (5.37)	19.00 (4.44)	141.33 (11.91)	140.00 (11.85)	131.00 (11.43)	121.00 (11.02)	102.00 (10.09)	79.67 (8.88)	38.67 (6.26)	26.00 (5.17)	16.67 (4.30)
1:50	140.33 (11.84)	138.33 (11.75)	132.00 (11.49)	127.33 (11.28)	117.00 (10.75)	99.00 (9.97)	55.67 (7.57)	45.00 (6.71)	26.67 (5.27)	141.33 (11.90)	141.67 (11.91)	139.67 (11.79)	132.33 (11.51)	111.67 (10.54)	100.67 (10.05)	50.33 (7.14)	43.33 (6.53)	22.33 (5.01)
Control	138.33 (11.80)	137.67 (11.74)	134.67 (11.64)	133.67 (11.53)	129.33 (11.40)	127.67 (11.49)	114.00 (10.85)	116.33 (10.91)	111.33 (10.62)	142.00 (11.92)	142.00 (11.92)	141.00 (11.87)	140.00 (11.82)	138.67 (11.77)	138.67 (11.68)	129.00 (11.37)	128.00 (11.36)	126.67 (10.89)
SEm±	0.04	0.05	0.07	0.09	0.16	0.13	0.19	0.14	0.05	0.02	0.04	0.07	0.07	0.11	0.09	0.12	0.09	0.10
C.D. 5%	0.12	0.14	0.20	0.27	0.46	0.36	0.53	0.40	0.14	0.05	0.10	0.19	0.19	0.30	0.25	0.34	0.25	0.30
C.V. (%)	0.74	0.86	1.30	1.91	3.61	3.24	6.34	5.72	2.48	0.31	0.63	1.21	1.32	2.29	2.16	4.04	3.51	5.34

Table 2. Interaction of *A. finlandicus* with *O. indicus* (Eggs pooled)

Ratio		Pooled								
		Pre treatment	4 DAR	8 DAR	12 DAR	16 DAR	20 DAR	24 DAR	28 DAR	32 DAR
1:10		140.33(11.80)	122.50(11.10)	76.83(8.75)	49.50(7.08)	29.83(5.54)	16.50(4.10)	3.83(1.88)	0.00(0.71)	0.00(0.70)
1:20		139.67(11.81)	129.00(11.32)	94.17(9.70)	69.17(8.30)	53.67(7.34)	33.00(5.88)	13.33(3.60)	4.17(2.16)	0.00(0.70)
1:30		140.67(11.87)	133.33(11.59)	122.33(11.07)	108.17(10.37)	85.67(9.39)	53.17(7.39)	25.67(5.08)	15.00(3.94)	3.33(1.97)
1:40		139.83(11.83)	136.50(11.70)	129.50(11.36)	119.17(10.94)	96.83(9.85)	76.17(8.72)	38.50(6.26)	26.33(5.27)	17.83(4.37)
1:50		140.83(11.87)	140.00(11.83)	135.83(11.64)	129.83(11.39)	114.33(10.64)	99.83(10.01)	53.00(7.36)	44.17(6.62)	24.50(5.14)
Control		140.17(11.86)	139.83(11.83)	137.83(11.76)	136.83(11.68)	134.00(11.59)	133.17(11.49)	121.50(11.11)	122.17(11.13)	119.00(10.75)
Y	SEm±	0.014	0.018	0.028	0.033	0.055	0.044	0.064	0.048	0.033
	C.D. 5%	0.039	0.050	0.078	0.094	0.158	0.126	0.181	0.137	0.095
T	SEm±	0.024	0.031	0.048	0.057	0.096	0.077	0.111	0.083	0.058
	C.D. 5%	0.067	0.087	0.135	0.163	0.273	0.219	0.314	0.237	0.164
Y x T	SEm±	0.033	0.043	0.067	0.081	0.136	0.109	0.156	0.118	0.082
	C.D. 5%	0.095	0.123	0.192	0.231	0.386	0.309	0.444	0.335	0.232
C.V. (%)		0.56	0.75	1.26	1.63	3.00	2.74	5.32	4.74	4.15

Figures in the parentheses are square root transformed values. DAR= Days After Release

Table 3. Interaction of *A. finlandicus* with *O. indicus* (Nymphs)

Ratio	2014-15									2015-16								
	Pre treatment	4 DAR	8 DAR	12 DAR	16 DAR	20 DAR	24 DAR	28 DAR	32 DAR	Pre treatment	4 DAR	8 DAR	12 DAR	16 DAR	20 DAR	24 DAR	28 DAR	32 DAR
1:10	39.67 (6.34)	33.67 (5.76)	21.00 (4.58)	17.67 (4.18)	13.00 (3.63)	5.33 (2.35)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	38.00 (6.22)	32.00 (5.60)	19.00 (4.41)	16.00 (3.97)	11.33 (3.37)	4.33 (2.12)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
1:20	42.33 (6.50)	40.67 (6.38)	32.67 (5.74)	23.33 (4.82)	16.67 (4.12)	11.67 (3.45)	6.33 (2.66)	0.00 (0.71)	0.00 (0.71)	40.33 (6.30)	39.33 (6.28)	30.33 (5.54)	20.00 (4.53)	13.00 (3.67)	8.67 (3.04)	4.67 (2.23)	0.00 (0.71)	0.00 (0.71)
1:30	41.00 (6.36)	41.00 (6.36)	37.33 (6.08)	33.00 (5.79)	27.00 (5.20)	21.67 (4.65)	13.33 (3.70)	5.00 (2.38)	0.00 (0.71)	40.00 (6.24)	40.00 (6.24)	35.67 (5.93)	31.33 (5.66)	25.33 (5.10)	18.33 (4.24)	10.33 (3.42)	3.67 (1.98)	0.00 (0.71)
1:40	39.33 (6.26)	40.00 (6.28)	39.33 (6.24)	37.00 (6.08)	34.67 (5.89)	30.00 (5.46)	24.67 (5.04)	14.67 (3.84)	5.67 (2.33)	37.67 (6.08)	38.00 (6.12)	37.67 (6.06)	35.00 (5.92)	31.00 (5.63)	26.00 (5.05)	18.33 (4.49)	12.33 (3.57)	3.33 (1.99)
1:50	39.67 (6.28)	41.00 (6.40)	41.00 (6.42)	40.00 (6.36)	38.00 (6.20)	34.33 (5.88)	39.00 (6.23)	21.67 (4.72)	11.00 (2.39)	39.67 (6.26)	39.00 (6.26)	40.33 (6.34)	39.33 (6.28)	31.00 (5.70)	31.33 (5.66)	32.33 (5.83)	20.33 (4.58)	10.00 (3.31)
Control	39.00 (6.24)	40.67 (6.38)	40.67 (6.38)	40.67 (6.40)	40.33 (6.36)	40.00 (6.39)	40.67 (6.44)	39.00 (6.30)	38.33 (6.27)	38.00 (6.16)	40.67 (6.38)	39.67 (6.32)	41.00 (6.40)	40.33 (6.36)	40.00 (6.36)	40.67 (6.40)	39.00 (6.30)	38.33 (6.24)
SEm±	0.07	0.09	0.07	0.06	0.09	0.07	0.09	0.09	0.04	0.07	0.09	0.08	0.06	0.12	0.07	0.10	0.09	0.07
C.D. 5%	0.19	0.26	0.19	0.18	0.25	0.20	0.25	0.25	0.11	0.21	0.27	0.22	0.16	0.35	0.20	0.30	0.25	0.20
C.V. (%)	2.12	2.90	2.22	2.24	3.33	3.01	4.17	5.56	3.35	2.41	3.06	2.64	2.05	4.88	3.16	5.40	5.84	6.03

Table 4. Interaction of *A. finlandicus* with *O. indicus* (Nymphs pooled)

Ratio		Pooled								
		Pre treatment	4 DAR	8 DAR	12 DAR	16 DAR	20 DAR	24 DAR	28 DAR	32 DAR
1:10		38.83(6.28)	32.83(5.68)	20.00(4.50)	16.83(4.08)	12.17(3.50)	4.83(2.23)	0.00(0.71)	0.00(0.71)	0.00(0.71)
1:20		41.33(6.40)	40.00(6.33)	31.50(5.64)	21.67(4.67)	14.83(3.90)	10.17(3.24)	5.50(2.45)	0.00(0.71)	0.00(0.71)
1:30		40.50(6.30)	40.50(6.30)	36.50(6.01)	32.17(5.72)	26.17(5.15)	20.00(4.45)	11.83(3.56)	4.33(2.18)	0.00(0.71)
1:40		38.50(6.17)	39.00(6.20)	38.50(6.15)	36.00(6.00)	32.83(5.76)	28.00(5.26)	21.50(4.76)	13.50(3.70)	4.50(2.16)
1:50		39.67(6.27)	40.00(6.33)	40.67(6.38)	39.67(6.32)	34.50(5.95)	32.83(5.77)	35.67(6.03)	21.00(4.65)	10.50(3.35)
Control		38.50(6.20)	40.67(6.38)	40.17(6.35)	40.83(6.40)	40.33(6.36)	40.00(6.38)	40.67(6.42)	39.00(6.30)	38.33(6.26)
Y	SEm±	0.029	0.038	0.029	0.024	0.043	0.029	0.039	0.035	0.023
	C.D. 5%	0.083	0.107	0.082	0.069	0.123	0.081	0.111	0.101	0.065
T	SEm±	0.050	0.065	0.050	0.042	0.075	0.050	0.067	0.061	0.040
	C.D. 5%	0.143	0.186	0.143	0.120	0.212	0.141	0.192	0.174	0.113
Y x T	SEm±	0.071	0.092	0.071	0.059	0.106	0.070	0.095	0.087	0.056
	C.D. 5%	0.202	0.263	0.202	0.169	0.300	0.200	0.271	0.246	0.159
	C.V. (%)	2.27	2.98	2.43	2.15	4.14	3.08	4.78	5.70	4.83

Figures in the parentheses are square root transformed values. DAR= Days After Release

Table 5. Interaction of *A. finlandicus* with *O. indicus* (Adults)

Ratio	2014-15									2015-16								
	Pre treatment	4 DAR	8 DAR	12 DAR	16 DAR	20 DAR	24 DAR	28 DAR	32 DAR	Pre treatment	4 DAR	8 DAR	12 DAR	16 DAR	20 DAR	24 DAR	28 DAR	32 DAR
1:10	28.00 (5.29)	25.67 (5.07)	21.33 (4.66)	18.67 (4.36)	14.67 (3.87)	11.67 (3.49)	9.33 (3.18)	4.33 (2.17)	0.00 (0.71)	30.33 (5.50)	26.67 (5.17)	21.67 (4.66)	17.33 (4.18)	13.67 (3.67)	9.67 (3.05)	5.33 (2.49)	4.00 (1.93)	0.00 (0.71)
1:20	29.33 (5.41)	28.67 (5.36)	26.67 (4.17)	25.00 (5.02)	23.67 (4.84)	21.33 (4.66)	17.33 (4.21)	15.33 (3.73)	6.00 (2.48)	30.33 (5.50)	28.67 (5.36)	25.67 (5.10)	23.33 (4.87)	21.00 (4.64)	17.33 (4.16)	9.67 (3.37)	8.33 (2.95)	3.67 (2.00)
1:30	29.33 (5.38)	29.67 (5.41)	28.67 (5..4)	27.67 (5.24)	26.33 (5.10)	25.00 (4.95)	22.00 (4.66)	19.67 (4.27)	11.33 (3.40)	31.00 (5.55)	30.00 (5.48)	28.67 (5.34)	26.33 (5.12)	24.67 (4.92)	20.33 (4.53)	16.33 (4.04)	13.33 (3.60)	8.67 (3.00)
1:40	29.67 (5.43)	30.33 (5.48)	29.67 (5.45)	29.33 (5.43)	28.33 (5.32)	28.00 (5.29)	25.67 (5.07)	17.33 (4.16)	16.67 (3.97)	30.67 (5.52)	30.67 (5.52)	30.00 (5.45)	27.67 (5.24)	25.33 (5.05)	23.00 (4.81)	20.33 (4.50)	14.33 (3.74)	11.67 (3.46)
1:50	29.67 (5.41)	30.00 (5.45)	30.33 (5.50)	30.00 (5.48)	29.67 (5.42)	29.33 (5.41)	28.00 (5.19)	26.00 (5.05)	21.33 (4.60)	30.33 (5.52)	31.00 (5.59)	31.00 (5.57)	30.00 (5.48)	25.67 (5.10)	24.33 (4.94)	23.33 (4.74)	20.67 (4.55)	16.67 (4.15)
Control	29.67 (5.43)	29.67 (5.45)	30.33 (5.52)	30.33 (5.52)	30.33 (5.58)	30.67 (5.55)	30.33 (5.52)	30.33 (5.72)	30.00 (5.72)	30.67 (5.55)	31.00 (5.59)	31.67 (5.63)	30.33 (5.52)	31.00 (5.57)	30.33 (5.36)	30.33 (5.29)	30.33 (5.50)	30.33 (5.55)
SEm±	0.04	0.04	0.05	0.04	0.04	0.06	0.10	0.12	0.08	0.02	0.03	0.03	0.04	0.05	0.04	0.09	0.07	0.05
C.D. 5%	0.11	0.13	0.14	0.11	0.12	0.18	0.28	0.35	0.23	0.07	0.09	0.09	0.12	0.15	0.11	0.26	0.21	0.15
C.V. (%)	1.49	1.65	1.82	1.55	1.75	2.63	4.26	5.87	4.62	0.86	1.11	1.14	1.65	2.12	1.73	4.43	3.92	3.25

Table 6. Interaction of *A. finlandicus* with *O. indicus* (Adults pooled)

Ratio		Pooled								
		Pre treatment	4 DAR	8 DAR	12 DAR	16 DAR	20 DAR	24 DAR	28 DAR	32 DAR
1:10		29.17(5.40)	26.17(5.12)	21.50(4.66)	18.00(4.27)	14.17(3.77)	10.67(3.27)	7.33(2.83)	4.17(2.05)	0.00(0.71)
1:20		29.83(5.45)	28.67(5.36)	26.17(5.13)	24.17(4.95)	22.33(4.74)	19.33(4.41)	13.50(3.79)	11.83(3.34)	4.83(2.24)
1:30		30.17(5.46)	29.83(5.44)	28.67(5.34)	27.00(5.18)	25.50(5.01)	22.67(4.74)	19.17(4.35)	16.50(3.93)	10.00(3.20)
1:40		30.17(5.48)	30.50(5.50)	29.83(5.45)	28.50(5.34)	26.83(5.18)	25.50(5.05)	23.00(4.79)	15.83(3.95)	14.17(3.72)
1:50		30.00(5.47)	30.50(5.52)	30.67(5.53)	30.00(5.48)	27.67(5.26)	26.83(5.17)	25.67(4.96)	23.33(4.80)	19.00(4.38)
Control		30.17(5.49)	30.33(5.52)	31.00(5.58)	30.33(5.52)	30.67(5.57)	30.50(5.45)	30.33(5.41)	30.33(5.61)	30.17(5.63)
Y	SEm±	0.014	0.016	0.016	0.017	0.019	0.022	0.039	0.041	0.028
	C.D. 5%	0.038	0.044	0.046	0.048	0.055	0.062	0.110	0.117	0.079
T	SEm±	0.023	0.027	0.028	0.029	0.034	0.037	0.067	0.071	0.048
	C.D. 5%	0.067	0.076	0.080	0.082	0.096	0.107	0.190	0.203	0.136
Y x T	SEm±	0.033	0.038	0.040	0.041	0.048	0.053	0.095	0.101	0.068
	C.D. 5%	0.094	0.108	0.114	0.116	0.136	0.151	0.269	0.287	0.193
	C.V. (%)	1.21	1.40	1.51	1.60	1.94	2.26	4.34	5.11	4.07

Figures in the parentheses are square root transformed values. DAR= Days After Release

Table 7. Interaction of *A. finlandicus* with *O. indicus* (Total population)

Ratio	2014-15									2015-16								
	Pre treatment	4 DAR	8 DAR	12 DAR	16 DAR	20 DAR	24 DAR	28 DAR	32 DAR	Pre treatment	4 DAR	8 DAR	12 DAR	16 DAR	20 DAR	24 DAR	28 DAR	32 DAR
1:10	207.33 (14.35)	182.00 (13.48)	117.33 (10.92)	83.00 (9.18)	53.33 (7.50)	32.00 (5.78)	32.00 (3.66)	4.33 (1.99)	0.00 (0.71)	209.33 (14.48)	181.00 (13.48)	119.33 (10.86)	85.67 (9.27)	59.00 (7.65)	32.00 (5.64)	9.67 (3.13)	4.00 (1.83)	0.00 (0.71)
1:20	209.67 (14.47)	196.33 (13.96)	153.33 (12.41)	111.67 (10.64)	90.67 (9.61)	67.67 (8.39)	67.67 (6.26)	20.00 (4.50)	6.00 (2.43)	212.00 (14.53)	199.00 (14.12)	150.33 (12.28)	118.33 (10.90)	91.00 (9.54)	57.33 (7.80)	26.33 (5.37)	12.00 (3.76)	3.67 (2.00)
1:30	210.33 (14.49)	201.00 (14.20)	185.67 (13.59)	168.33 (12.98)	136.67 (11.72)	98.33 (9.99)	98.33 (7.76)	38.33 (6.20)	15.00 (3.86)	212.33 (14.53)	206.33 (14.33)	189.33 (13.77)	166.33 (12.83)	138.00 (11.80)	93.33 (9.74)	52.67 (7.29)	33.33 (5.75)	11.67 (3.50)
1:40	207.33 (14.38)	203.33 (14.24)	197.00 (14.00)	183.67 (13.58)	154.67 (12.48)	130.67 (11.47)	130.67 (9.50)	58.67 (7.78)	41.33 (6.19)	209.67 (14.47)	208.67 (14.44)	198.67 (14.04)	183.67 (13.55)	158.33 (12.61)	128.67 (11.30)	77.33 (8.94)	52.67 (7.31)	31.67 (5.68)
1:50	209.67 (14.46)	209.33 (14.45)	203.33 (14.27)	197.33 (14.06)	184.67 (13.55)	162.67 (12.78)	162.67 (11.14)	92.67 (9.64)	59.00 (7.52)	211.33 (14.53)	211.67 (14.57)	211.00 (14.50)	201.67 (14.20)	168.33 (13.02)	156.33 (12.53)	106.00 (10.48)	84.33 (9.19)	49.00 (7.03)
Control	207.00 (14.41)	208.00 (14.43)	205.67 (14.38)	204.67 (14.30)	200.00 (14.18)	198.33 (14.10)	198.33 (13.67)	185.67 (13.63)	179.67 (13.99)	210.67 (14.52)	213.67 (14.63)	212.33 (14.59)	211.33 (14.54)	210.00 (14.49)	209.00 (14.26)	200.00 (13.78)	197.33 (13.80)	195.33 (14.02)
SEm±	0.04	0.07	0.08	0.09	0.15	0.12	0.15	0.12	0.11	0.04	0.06	0.06	0.06	0.11	0.09	0.15	0.16	0.07
C.D. 5%	0.12	0.19	0.24	0.25	0.43	0.33	0.42	0.35	0.31	0.11	0.16	0.16	0.16	0.33	0.26	0.43	0.46	0.21
C.V. (%)	0.57	0.92	1.25	1.39	2.61	2.25	3.39	3.38	3.71	0.54	0.79	0.83	0.92	1.99	1.78	3.72	4.67	2.70

Table 8. Interaction of *A. finlandicus* with *O. indicus* (Total pooled)

Ratio		Pooled								
		Pre treatment	4 DAR	8 DAR	12 DAR	16 DAR	20 DAR	24 DAR	28 DAR	32 DAR
1:10		208.33(14.42)	181.50(13.48)	118.33(10.89)	84.33(9.22)	56.17(7.58)	32.00(5.71)	11.17(3.39)	4.17(1.91)	0.00(0.71)
1:20		210.83(14.50)	197.67(14.04)	151.83(12.34)	115.00(10.77)	90.83(9.58)	62.50(8.06)	32.33(5.81)	16.00(4.13)	4.83(2.21)
1:30		211.33(14.51)	203.67(14.27)	187.50(13.68)	167.33(12.91)	137.33(11.76)	95.83(9.86)	56.67(7.53)	35.83(5.98)	13.33(3.68)
1:40		208.50(14.42)	206.00(14.34)	197.83(14.02)	183.67(13.56)	156.50(12.54)	129.67(11.38)	83.00(9.22)	55.67(7.54)	36.50(5.93)
1:50		210.50(14.50)	210.50(14.51)	207.17(14.38)	199.50(14.13)	176.50(13.29)	159.50(12.65)	114.33(10.81)	88.50(9.41)	54.00(7.28)
Control		208.83(14.47)	210.83(14.53)	209.00(14.48)	208.00(14.42)	205.00(14.33)	203.67(14.18)	192.50(13.72)	191.50(13.72)	187.50(14.01)
Y	SEm±	0.016	0.025	0.029	0.030	0.055	0.043	0.061	0.059	0.038
	C.D. 5%	0.047	0.071	0.082	0.085	0.155	0.122	0.173	0.167	0.107
T	SEm±	0.028	0.043	0.050	0.052	0.095	0.074	0.106	0.102	0.065
	C.D. 5%	0.081	0.122	0.142	0.148	0.269	0.211	0.300	0.289	0.186
Y x T	SEm±	0.040	0.061	0.070	0.073	0.134	0.105	0.149	0.144	0.092
	C.D. 5%	0.114	0.173	0.200	0.209	0.380	0.298	0.425	0.409	0.263
	C.V. (%)	0.55	0.86	1.06	1.17	2.32	2.03	3.55	4.05	3.27

Figures in the parentheses are square root transformed values. DAR= Days After Release

indicus at 1:10 ratio before release of *A. finlandicus* was 207.33 per leaf which reduced and reached to zero at 32 DAR due to predation; while, during the year 2015-16 the initial population was 209.33 per leaf which was completely eliminated at 32 DAR (Table 7). The initial population during the year 2014-15 at 1:20, 1:30, 1:40 and 1:50 ratios was 209.67, 210.33, 207.33 and 209.67 per leaf, respectively, which reduced and reached to 6.00, 15.00, 41.33 and 59.00 per leaf, respectively at 32 DAR. Whereas, in the year 2015-16 the initial population of *O. indicus* at 1:20, 1:30, 1:40 and 1:50 ratios was 212.00, 212.33, 209.67 and 211.33 per leaf, respectively, which reached to 3.67, 11.67, 31.67 and 49.00 per leaf, respectively at 32 DAR after predation. The pooled data reveal that the interaction (Y x T) was found non significant, exhibiting similar response of predator to prey population over years (Table 8). The initial population at 1:10 ratio was 208.33 per leaf which reached to zero at 32 DAR. At 1:20, 1:30, 1:40 and 1:50 ratios the total population of *O. indicus* before release of gravid females of *A. finlandicus* was 210.83, 211.33, 208.50 and 210.50 per leaf, respectively which was gradually decreased by predator and reached to 4.83, 13.33, 36.50 and 54.00 per leaf, respectively at 32 DAR. Dhooria (1981) studied the interaction between *A. alstoniae* and *E. orientalis* on citrus and found that at different predator prey ratios, *A. alstoniae* effectively reduced the prey population. Shah and Shukla (2014) reported that at 1:10 ratio, *A. longispinosus* caused maximum reduction of *T. urticae* within 20 days after release. Further, Mahendrakumar and Shukla (2016) also recorded similar results at 1:10 predator prey ratio and found *A. alstoniae* caused maximum reduction of prey mite on brinjal. Likewise Chauhan and Shukla (2016) recorded maximum reduction of *T. urticae* at 1:10 ratio within twenty days after release of predatory mite, *A.longispinosus*. Mandapee *et al.* (2018) also reported the effectiveness of *A. alstoniae* against the sorghum mite, *O. indicus*. Wilson *et al*. (1983) reported that at 1:10 ratio the predatory mite, *M. occidentalis* reduced the population of tetranychid mite significantly and gave good control within two weeks. These reports are more or less in accordance with the present research results. However, slight difference may be due to difference in the prey species, rearing technique and climatic conditions.

ACKNOWLEDGEMENT

Authors wish to extend their gratitude to the Principal, N.M. College of Agriculture, Navsari, Director of Research and Dean Post Graduate Studies, Navsari Agricultural University, Navsari, India, for providing necessary support to carry out our work.

REFERENCES

Chauhan, R. and Shukla, A. 2016. Interaction between predatory mite, *Neoseiulus longispinosus* (Evens) and spider mite *Tetranychus urticae* Koch on french bean (*Phaseolus vulgaris* L.). *International Journal on Agricultural Sciences*, **7**:180-185.

Chillar, B. S., Gulati, R. and Bhatnagar, P. 2007. Agricultural Acarology. Daya Publishing House, Delhi, pp- 355.

Cox, P.D., Matthews, L , Jacobson, R.J. , Cannon, R., MacLeod , A. and Walters, K.F.A. 2006**.** Potential for the use of biological agents for the control of *Thrips palmi* (Thysanoptera: Thripidae) outbreaks. *Biocontrol Science & Technology,* **16**:871–891.

Dhooria, M. S. 1981. Feeding behaviour of predatory mites, thrips and bettles of the citrus mite, *Eutetranychus orientalis. Acarology Newsleter*, **10**:4-6.

Kropczynska, D. and Tuovinen, T. 1988. Occurrence of Phytoseiid mites (Acari: Phytoseiidae) on apple trees in Finland. *Annales Agriculturae Fenniae*, **27**: 305-314.

Mahendrakumar, B.N. and Shukla, A. 2016. Interaction between predatory mite, *Amblyseius alstoniae* (Acari : Phytoseiidae) and two spotted spider mite, *Tetranychus urticae* (Acari: Tetranychidae) on brinjal. *Journal of Experimental Zoology India,* **19**:793-797.

Mandape, S., Shukla, A. and Radadia, G.G. 2018. Interaction between predatory mite, *Amblyseius alstoniae* Gupta and sorghum mite, *Oligonychus indicus* (Hirst). *Trends in Biosciences* **11**:341-347.

Mandape, S. and Shukla, A. 2017[a]. Effect of alternate food sources on predatory Mite *Amblyseius finlandicus* (Oudeman) (Acari: Phytoseiidae). *International Journal of Current Microbiology & Applied Science*, **6**:1265-1274.

Mandape, S.and Shukla, A. 2017[b]. Effect of alternate food sources on some biological parameters of predatory mite, *Amblyseius longispinosus* (Evans) (Acari: Phytoseiidae). *Trends in Biosciences*, **10** :4466-4471.

McMurtry, J. A. and Croft, B. A. 1997. Life-styles of phytoseiid mites and their roles in biological control. *Annual Review of Entomology*, **42**:291-321.

Messelink, G.J., Bloemhard, C. M. J. , Sabelis, M. W. and Janssen, A. 2013. Biological control of aphids in the presence of thrips and their enemies. *Biocontrol*, **58**:45-55.

Messelink, G.J., Rv, M., van Steenpaal, S.E.F. and Janssen, A. 2008. Biological control of thrips and whiteflies by a shared predator: Two pests are better than one. *Biological Control*, **44**:372–379.

Messelink, G.J., van Maanen, R., van Holstein-Saj, R, Sabelis, M.W. and Janssen, A. 2010. Pest species diversity enhances control of spider mites and whiteflies by a generalist phytoseiid predator. *Biocontrol*, **55**:387-398.

Messelink, G.J., van Steenpaal, S.E.F and Janssen, A. 2008. Biological control of thrips and whiteflies by a shared predator: Two pests are better than one. *Biological Control*, **44**:372–379.

Momen, F., M. and El-Borolossy. 2010. Juvenile survival and development in three phytoseiid species (Acari: Phytoseiidae) feeding on con- and heterospecific immatures. *Acta Phytopathologica et Entomologica Hungarica*, **45**:349-357.

NeelamKumari 1981. Biology and ecology of the predatory mite, *Amblyseius finlandicus* (Oudemans) and is evaluation as biological control agent. Ph. D. thesis, Punjab Agricultural University, Ludhiana, Punjab, pp. 207.

Ragusa-Di Chiara, S., Papaioannou- Souliotis, P., Tsolakis, H. and Tsagarakou, N. 1995. Acari fitoseidi (Parasitiformes, Phytoseiidae) della Greciaassociati a pianteforestali a diverse altitudini. *Boll. Zool. agric. Bachic. Ser*. II, **27**:85-91.

Shah, D. and Shukla, A. 2014. Interaction between predatory mite, *Amblyseius longispinosus* (Evans) and two spotted spider mite *Tetranychus urticae* Koch on gerbera. *Journal of Applied Biosciences,* **4**:105-109.

Wilson, L. T., Gonzaleaz, D., Leight, T. F., Maggi, V., Foristecere, C. and Goodell, P. 1983. Within plant distribution of spider mites (Acari: Tetranychidae) on cotton developing a implementable monitoring programe. *Environmental Entomology*,12:128-134.

Received: 07.01.2018 Accepted: 20.05.2018