



Research Article

Diversity of phytophagous and predatory mites in vegetable crops in Himachal Pradesh, India

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ABSTRACT: The surveys carried out in different vegetable growing areas of Himachal Pradesh yielded 25 species of mites belonging to 9 genera under 5 families. Among all, 5 species were phytophagous, 19 were predatory mites and 1 species was of saprophagous mite. On capsicum, a predatory mite of the family Anystidae was recorded for the first time from the state. During the study, majority of predatory mites were recorded on cucumber and brinjal than other vegetables. Four species are the new reports from Himachal Pradesh.

KEYWORDS: Mites, phytophagous, Phytoseiidae, predatory, saprophagous

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INTRODUCTION

The diverse climatic conditions of Himachal Pradesh favour the cultivation of different horticultural crops especially vegetables, which are an important part of the human diet due to their rich nutritional content. Farmers of the state produce them on a commercial basis in a protected and open environment. These crops harbour a great diversity of arthropod fauna which include pests as well as natural enemies. Mites are among them and act as important pests and natural enemies of phytophagous mites and soft-bodied arthropods. They survive well on these crops mainly under protected conditions (Channabasavanna, 1971). According to Prasad and Singh (2007) and Singh and Singh (1996) spider mites are more serious and result in massive loss of vegetable crops. Average loss to vegetable crops due to mite infestation was estimated from 9.15 to 100% (Vinothkumar *et al.* 2009; Patil & Nandihalli, 2009). To facilitate an effective management practice it's important to know their identity, host crops, distribution and their natural enemy complex. Not much detailed information was available on mite fauna in vegetable crops except for Singh and Chauhan (2014). Hence, the present study was taken up to document

the phytophagous and predatory mites occurring in vegetable crops.

MATERIALS AND METHODS

The investigation was conducted from 2014-2020 in different localities of six districts of Himachal Pradesh. Different localities of various districts in the state viz. Nauni, Chail, Mahogbag, Chambaghat, Jatoli, Kandaghat (Solan), Rajgarh, Kheradhar (Sirmaur), Sandu, Theog (Shimla), Kalpa, Giabong (Kinnaur), Bajaura, Seobag, Patlikuhl (Kullu), Sarkaghat, Dhanrashi, Sundernagar (Mandi), Nurpur, Jach (Kangra) were surveyed (Table 1, Figure 1). Leaves were collected after examination with a 10X hand lens and stored in properly tied polythene bags. After microscopic examination, the specimens were mounted in Hoyer's media (Jeppson *et al.*, 1975). For the identification and classification of phytophagous mites, Gupta and Gupta (1994) and Gupta (2003) literature were followed. Predatory mites of the family Phytoseiidae were identified and classified according to the classification system of Chant and McMurtry (2007). The diversity indices were calculated as per the Shannon diversity index (Shannon, 1948).



Zone-I	Hamirpur, Kangra	(365-914 m amsl)
Zone-II	Solan, Sirmaur, Kullu, Mandi	(915-1523 m amsl)
Zone-III	Shimla	(1524-2742 m amsl)
Zone-IV	Kinnaur	(above 2742 m amsl)

Figure 1. Different districts of Himachal Pradesh surveyed.

Table 1. Districts and localities surveyed

1.	Hamirpur	Hamirpur, Neri
2.	Kangra	Nurpur, Jach
3.	Solan	Nauni, Chail, Mahogbag, Chambaghat, Jatoli, Kandaghat
4.	Sirmaur	Kheradhar
5.	Kullu	Bajoura, Seobag, Patlikuhl
6.	Mandi	Sundernagar, Sarkaghat, Dhanrashi, Bajoura
7.	Shimla	Sandhu, Theog
8.	Kinnaur	Kalpa, Gaibong

RESULTS AND DISCUSSIONS

During the study, twenty-five mite species under five families and nine genera were identified from different vegetables viz. cucumber, tomato, brinjal, capsicum, red cabbage, okra and beans from the state (Table 1). Of these species, five were phytophagous, nineteen predatory and one was a saprophagous mite. Phytophagous mites belong to one genus of Family Tetranychidae (Tables 1 and 2). Among predatory mites; seventeen phytoseiid species of five genera and one species each from family Stigmaeidae and Anystidae were identified. Along with these mites, one species of the

family Acaridae was also recorded (Tables 1 and 3). Species, *Tetranychus urticae* Koch, *ludeni* Zacher, *Tetranychus* sp. nov. nr. *ludeni*, *Tetranychus macfarlanei* Baker and Pritchard and *Tetranychus neocaledonicus* Andre were phytophagous mites (Figure 2). During the study two-spotted spider mite (*T. urticae*) was recorded as a serious pest on brinjal, red cabbage and okra, red spider mite (*T. ludeni*) was found on tomato and bean, One new species (*T. sp. nov. nr. ludeni*) was recorded on bean, spider mite (*T. macfarlanei*) was found to infest cucumber and on bean and brinjal vegetable spider mite (*T. neocaledonicus*) was recorded (Table 2).

Table 2. Phytophagous and predatory mites on vegetable crops in Himachal Pradesh, India

Host/ Habitat	Families (Predatory mites)			Family of Saprophagous mite	Family of phytophagous mites	Total
	Phytoseiidae	Stigmaeidae	Anystidae	Acaridae	Tetranychidae	
Cucumber	10 (<i>Amblyseius largoensis</i> , <i>A. herbicolus</i> , <i>A. cucurbitae</i> , <i>A. guajavae</i> , <i>Euseius prasadi</i> , <i>E. eucalypti</i> , <i>E. finlandicus</i> , <i>E. neococcineae</i> , <i>Neoseiulus</i> sp. nov. nr. <i>neoghani</i> and <i>Typhlodromus mori</i>)	1 (<i>A. fleschneri</i>)	-	1 (<i>A. gracilis</i>)	1 (<i>T. macfarlanei</i>)	13
Brinjal	9 (<i>A. multidentatus</i> , <i>A. chitradurgae</i> , <i>Euseius eucalypti</i> , <i>Neoseiulus</i> sp. nov. nr. <i>neoghani</i> , <i>Typhlodromus himalayensis</i> , <i>Phytoseius corniger</i> , <i>P. crinitus</i> and <i>P. kapuri</i> <i>P. sp. nov. nr. maldahensis</i>)	-	-	-	2 (<i>T. urticae</i> and <i>T. neocaledonicus</i>)	11
Tomato	1 (<i>N. sp. nov. nr. neoghani</i>)	-	-	-	1 (<i>T. ludeni</i>)	2
Capsicum	-	-	1 (<i>A. baccarum</i>)	-	-	1
Red cabbage	-	-	-	-	1 (<i>T. urticae</i>)	1
Bean	-	-	-	-	2 (<i>T. ludeni</i> , <i>T. sp. nov. nr. ludeni</i>)	2

Table 2. Phytophagous mites on vegetable crops from Himachal Pradesh, India

Family	Species	Host	Locality/District
Tetranychidae	<i>T. urticae</i>	Red cabbage (<i>Brassica oleracea</i> var. <i>capitata</i>), Brinjal (<i>Solanum melangena</i> L.), Okra (<i>Abelmoschus esculentus</i> (L. (Moench))	Nauni, Chail, Mahogbag (Solan), Dhanrashi, Sarkaghat (Mandi), Jach, Nurpur (Kangra), Neri (Hamirpur)
	<i>T. ludeni</i>	Tomato (<i>Solanum lycopersicum</i>), Bean (<i>Phaseolus vulgaris</i> L.)	Nauni (Solan), Rajgarh, Kheradhar (Sirmaour), Sandhu, Theog (Shimla), Kalpa, Gaibong (Kinnaur)
	<i>T. sp. nov. nr. ludeni</i>	Bean (<i>P. vulgaris</i>)	Bajaura, Seobag (Kullu)
	<i>T. macfarlanei</i>	Cucumber (<i>Cucumis sativus</i> L.)	Nauni (Solan)
	<i>T. neocaledonicus</i>	Bean (<i>P. vulgaris</i>), Brinjal (<i>S. melongena</i>)	Bajaura, Seobag, Patlikuhah (Kullu)

Table 3. Predatory mites on vegetable crops from Himachal Pradesh, India

Family	Species	Habitat	Locality/District
Phytoseiidae	<i>Amblyseius largoensis</i> (Muma)	Cucumber (<i>Cucumis sativu</i> sL.)	Nauni, Solan, Chambaghat (Solan)
	<i>Amblyseius herbicolus</i> (Chant)	Cucumber (<i>Cucumis sativus</i> L.)	Nauni, Jatoli (Solan)
	<i>Amblyseius cucurbitae</i> Rather	Cucumber (<i>Cucumis sativus</i> L.)	Nauni, Chail (Solan)
	<i>Amblyseius multidentatus</i> (Swirski and Shechter)	Brinjal (<i>Solanum melanogena</i> L.)	Sunder Nagar (Mandi)
	<i>Amblyseius guajavae</i> Gupta	Cucumber (<i>Cucumissativus</i> L.)	Nauni, Jatoli (Solan)
	<i>Amblyseius chitradurgae</i> Gupta	Brinjal (<i>Cucumismelanogena</i> L.)	Sarkaghat, Dhanrashi (Mandi)
	<i>Euseius prasadi</i> (Chant and McMurtry)	Cucumber (<i>Cucumissativus</i> L.)	Nauni, Kandhaghat, Chail (Solan)
	<i>Euseius finlandicus</i> (Oudemans)	Cucumber (<i>Cucumissativus</i> L.)	Nauni (Solan)
	<i>Euseius eucalypti</i> Ghai and Menon	Brinjal (<i>Solanummelanogena</i> L.)	Dhanrashi, Sarkaghat (Mandi)
	<i>Euseius neococcineae</i> Gupta	Cucumber (<i>Cucumis sativus</i> L.)	Nauni, Jatoli (Solan)
	<i>N. sp. nov. nr. neoghani</i>	Tomato (<i>Solanum lycopersicum</i> L.), Cucumber (<i>Cucumis sativa</i> L.), Brinjal (<i>Solanum melanogena</i> L.)	Seobag, Bajaura (Kullu)
	<i>Typhlodromus mori</i> Gupta	Cucumber (<i>Cucumis sativus</i> L.)	Seobag, Bajaura (Kullu)
	<i>Typhlodromus himalayensis</i> Gupta	Brinjal (<i>Solanum melanogena</i> L.)	Sarkaghat, Dhanrashi (Mandi)
	<i>Phytoseioides corniger</i> Wainstein	Brinjal (<i>Solanum melanogena</i> L.)	Sarkaghat, Dhanrashi (Mandi)
	<i>Phytoseioides crinitus</i> Swirski and Shechter	Brinjal (<i>Solanum melanogena</i> L.)	Sarkaghat, Dhanrashi (Mandi)
<i>Phytoseioides kapuri</i> Gupta	Brinjal (<i>Solanum melanogena</i> L.)	Sarkaghat, Dhanrashi (Mandi)	
<i>P. sp. nov. nr. maldahensis</i>	Brinjal (<i>Solanum melanogena</i> L.)	Sarkaghat, Dhanrashi (Mandi)	
Stigmaeidae	<i>Agistemus fleschneri</i> Summers	Cucumber (<i>Cucumis sativa</i> L.)	Nauni, Jatoli (Solan)
Anystidae	<i>Anystus baccarum</i> (Linnaeus)	Capsicum (<i>Capcicum</i> sp.)	Nauni (Solan)
Acaridae	<i>A. gracilis</i>	Cucumber (<i>Cucumis sativus</i> L.)	Nauni (Solan)

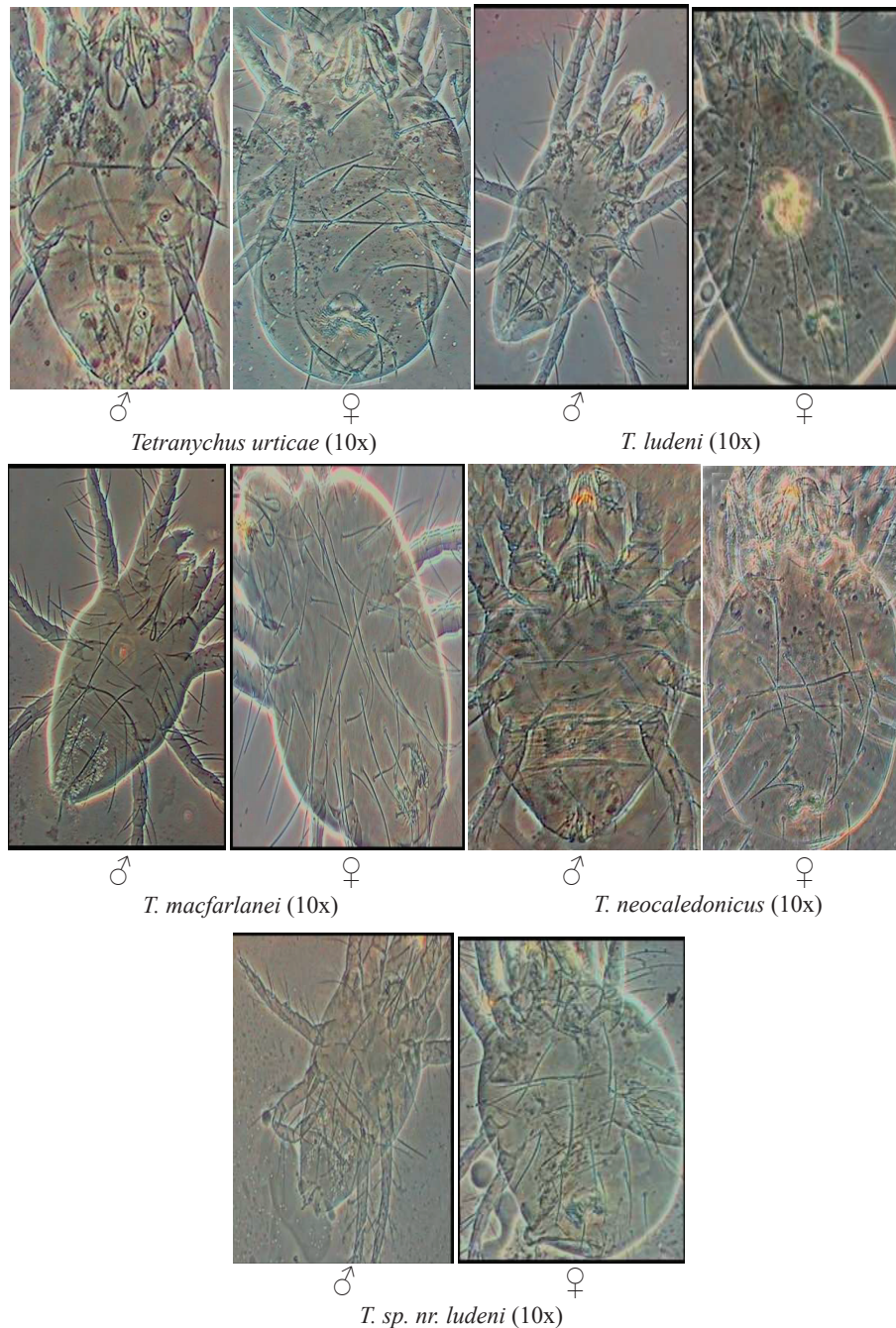


Figure 2. Phytoseioid mites of family Tetranychidae.

During the study, nineteen different predatory mites were recorded inhabiting different vegetable crops. 17 species of family Phytoseiidae and 1 species each of Stigmaeidae and Anystidae were recorded. Predatory species were viz. *Amblyseius largoensis* (Muma), *Amblyseius herbicolus* (Chant), *Amblyseius cucurbitae* Rather, *Amblyseius multidentatus* (Swirski&Shechter), *Amblyseius chitradurgae* Gupta, *Amblyseius guajavae* Gupta, *Euseius prasadi* (Chant and McMurty), *Euseius eucalypti* Ghai and Menon, *Euseius finlandicus* (Oudemans), *Euseius neococcineae* Gupta,

Neoseiulus sp. nr. *neoghonii*, *Typhlodromus mori* Gupta, *Typhlodromus himalayensis* Gupta, *Phytoseioides corniger* Wainstein, *Phytoseioides crinitus* Swirski and Shechter, *Phytoseioides kapuri* Gupta, *Phytoseioides* sp. nov. nr. *maldahensis*, *Agistemus fleschneri* Summers and *Anystus baccarum* (Linnaeus) (Figures 3-5). Among all predatory mites, ten Phytoseiid species along with one Stigmaeidae species were recorded on cucumber. Along with these predatory species, one saprophagous mite of family Acaridae viz. *Acarus gracilis* was also recorded. On brinjal, nine Phytoseiid species were

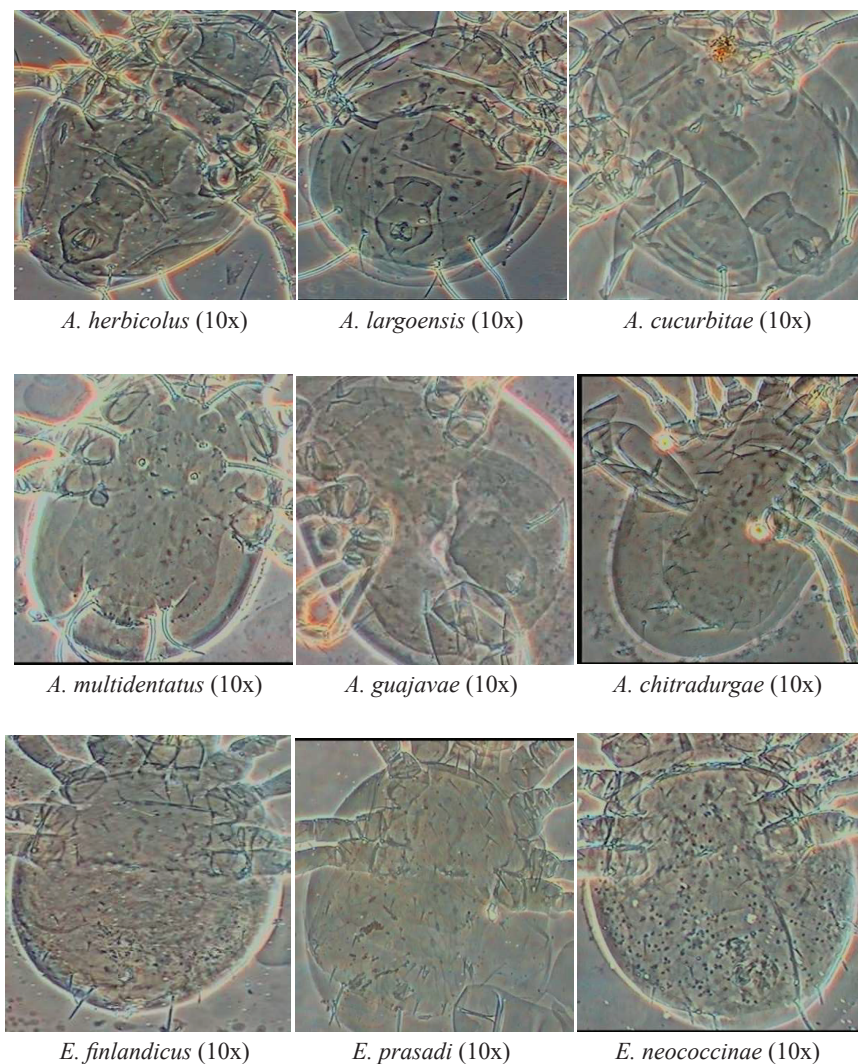


Figure 3. Predatory mites of family Phytoseiidae.

recorded (Tables 1 and 3). One species of Anystidae was recorded to inhabit capsicum (Tables 1 and 3). Among all recorded mites, two predatory mite species *viz.* *Neoseiulus* sp. nov. nr. *neoghanii* and *Phytoseiulus* sp. nov. nr. *maldhaensis* were found to inhabit cucumber, tomato and brinjal in Kullu and Mandi (Tables 1 and 3). During the study, the majority of predatory mites were recorded on cucumber and brinjal.

A study of diversity indices showed that *T. urticae* was the most abundant phytophagous mite (27.08%) which is recorded on different vegetables followed by *T. ludeni* (23.21%) and *T. macfarlanei* (21.28%) from the state (Tables 2 and 4). *T. neocaledonicus* (4.25%) and *T. sp. nr. ludeni* (3.87%) were found to be the least abundant. 08 species (33%) were found to be dominant in their distribution whereas 17 mite species (66%) were evenly distributed on investigated vegetable crops. Studies exhibited Shannon diversity index 2.16% (Table 4).

The results of mite diversity were supported by various studies in different areas. According to Basha *et al.* (2021), twelve species of mites were distributed on vegetables. Similarly, Bala *et al.* (2019) reported seventeen species of mites from different agri-horticultural and forest crops. Binisha and Bhaskar (2013) also reported nineteen species of mites from Kerala. Singh and Chauhan (2014) reported different mites on vegetable crops from Himachal Pradesh. Singh *et al.* (2000); and Rachana *et al.* (2009) also reported infestation of *T. urticae* on vegetable crops. *T. macfarlanei* was described as a serious pest of vegetable crops by various workers across the country (Singh & Chauhan, 2020; Rajgopal & Srinivasa, 2017). Infestation of *T. ludeni* on tomatoes and carnations was reported by Singh and Chauhan (2016b; 2018) but in the present study, this species was recorded on tomatoes and beans from the state. During the present investigation, an infestation of *T. neocaledonicus* was documented on beans and brinjal which was the new

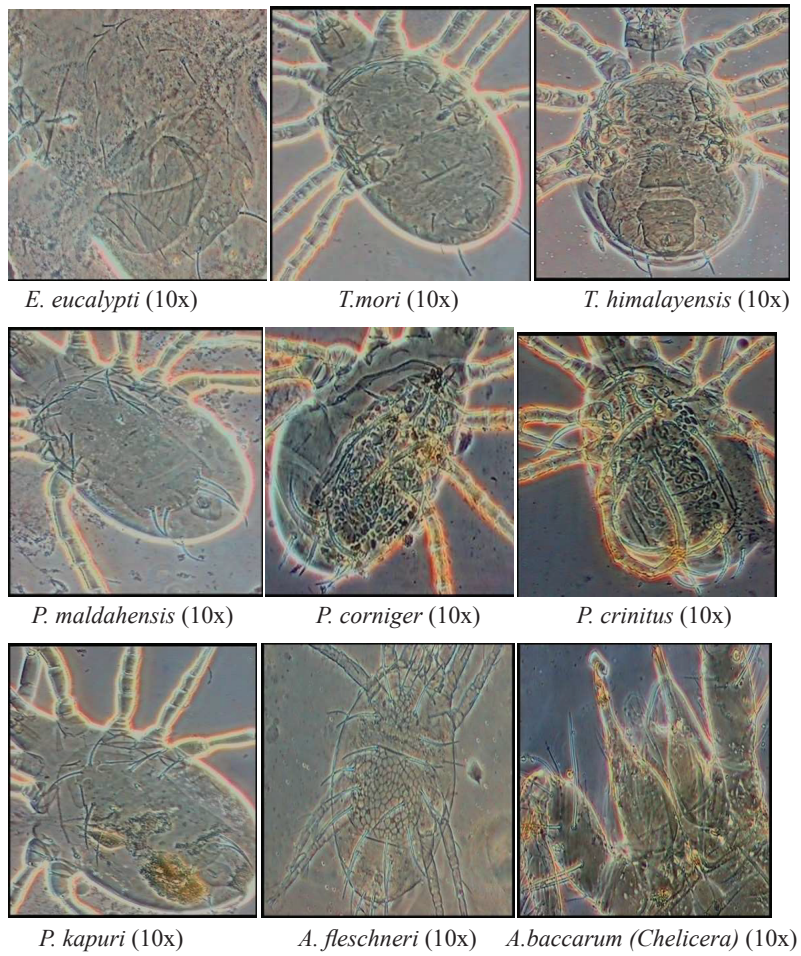
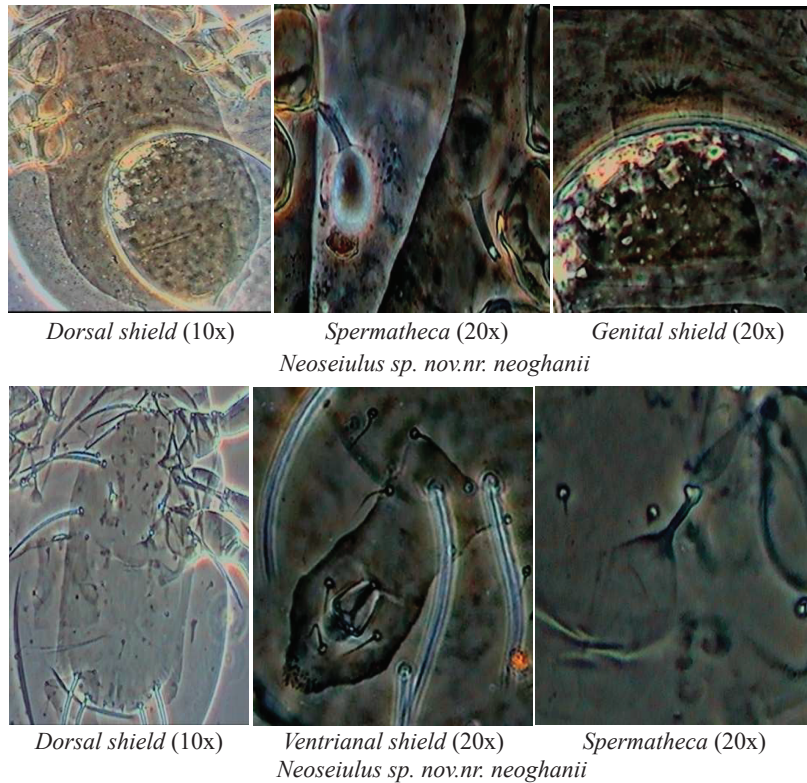


Figure 4. Predatory mites of different families.



*A. gracilis* (20x)**Figure 5.** Predatory and saprophagous mites.**Table 4.** Diversity indices of mites on vegetable crops in Himachal Pradesh, India

Mites	Relative proportion (%)
Phytophagous mites	
<i>T. urticae</i>	27.08
<i>T. ludeni</i>	23.21
<i>T. sp. nr. ludeni</i>	3.87
<i>T. macfarlanei</i>	21.28
<i>T. neocaledonicus</i>	4.25
Predatory mites	
<i>A. herbicolus</i>	2.51
<i>A. largoensis</i>	3.87
<i>A. cucurbitae</i>	0.77
<i>A. multidentatus</i>	0.77
<i>A. guajavae</i>	1.16
<i>Euseiuschitradurgae</i>	0.77
<i>E. finlandicus</i>	2.32
<i>E. prasadi</i>	1.16
<i>E. neococcinae</i>	0.77
<i>E. eucalypti</i>	0.39
<i>N. sp. nov.nr. neoghonii</i>	0.97
<i>T. (A.) mori</i>	0.58
<i>T. (A.) himalayensis</i>	1.16
<i>P. maldahensis</i>	0.39
<i>P. sp. nov.nr. maldahensis</i>	0.58
<i>P. corniger</i>	0.39
<i>P. crinitus</i>	0.39
<i>P. kapuri</i>	0.58
<i>A. fleschneri</i>	0.19
<i>A. baccarum</i>	0.58
<i>A. gracilis</i>	2.51
Total	100
Shannon index (H)	2.16
Hmax	3.22
Evenness (J)	0.66
Dominance (D)	0.33

report from the state on any vegetable. *T. neocaledonicus* was earlier reported on apple by Singh and Chauhan (2019) from the state.

In the present investigation, nineteen species of predatory mites are recorded on different vegetables. Earlier, mites of different families were reported on different vegetable and ornamental crops associated with phytophagous mites (Singh & Chauhan, 2021; 2020; 2018; 2017a; 2017b; 2016a; 2016b; 2014). Researchers reported fifteen species of predatory mites on vegetable crops from West Bengal. During their study, they reported *A. largoensis* as the leading predatory species after *Typhlodromips syzygii*. In the present investigation *N. sp. nov. nr. neoghani* was the most diverse species followed by *Euseius eucalypti*. Similarly, Basha *et. al.* (2021) reported nine species of predatory mites on vegetable crops. In the present study, three species were the new record. These species are *T. sp. nov. nr. ludeni*, *Neoseiulus sp. nov. nr. neoghani* and *P. sp. nov. nr. maldahensis*. These species require further studies for their introduction to the science. Phytoseiid mites are explored as dominant natural enemies of plant-feeding mites from various parts of the world on a variety of crops (Sadanandan & Ramani, 2006; Karmakar & Gupta, 2010). So it's very important to evaluate the potential of the predatory mites in taking down phytophagous mite population in vegetable crops.

CONCLUSION

It is evident from the investigation of various regions of the state that vegetables are the preferred habitat for predatory mites and the preferred host for phytophagous mites. During the study, 19 predatory mites were associated with 05 populous species of phytophagous mites which keep them under control to some extent on these crops. So, this study can be important from the point of potential predatory species and its utilization in productive biological control programmes.

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