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Impact of habitat variation on the species diversity and richness of phytoseiid predatory mites (*Acari: Mesostigmata*)- A case study from north Kerala

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Abstract
The present study was undertaken to generate data on the impact of habitat variations *viz*., open and closed (polyhouse) agro-ecosystems on the relative distribution pattern of predatory mites belonging to the family Phytoseiidae. Plant dwelling species of phytoseiid mites were recovered by collecting samples of aerial parts of economically important crops cultivated / grown in two different localities representing outdoor place condition as well as in polyhouses in the Kozhikode district of Kerala. The mite specimens were segregated from the plant samples through microscopic screening and the collected specimens were preserved, dehydrated and slide mounted in Hoyer's medium. Slide mounted specimens were oven dried and identified following relevant keys/literature as well as seeking confirmation from experts. Data on the species diversity and abundance of phytoseiid predators revealed the predominance of these mites in open habitats when compared to the polyhouse condition. Maximum number of phytoseiid mites could be collected from the outdoor of Kunnathukara Organic Farmhouse (Site IIo = 647) followed by outdoor of Kurumpoyil Farmhouse (Site Io = 160). The lowest numbers of phytoseiid were collected from the polyhouses. The diversity indices of all the ecosystems showed higher diversity and Kunnathukara Organic Farm showed highest diversity during the survey.

Keywords: *Amblyseius*, species diversity, phytoseiidae, abundance, species richness

Introduction

Phytoseiidae Berlese, 1913 constitutes a large family of extremely beneficial group of predatory mites, comprising 2798 described species, of which 2521 are listed as valid species under 82 genera (Demite PR *et al* 2012 &2014) [3, 4]. The extensive use of these mites in biological control programmes (Mc Murtry & Croft 1997; Gerson *et al.* 2003) [9], against pest mites and insects such as thrips, white flies, aphids and so on raise their commercial importance for subsequent import for field release by various countries. Many species of phytoseiids species have been proved as successful biological control agents of phytophagous mites and maintain their population below the economic injury levels, especially in green house conditions (Chant DA & Mc Murtry JA 2007; Gerson U & Weintraub P G. 2007) [1, 5]. A knowledge on the faunal diversity of these mites and the factors which determine their preferential distribution in different microhabitats is highly essential for understanding the behavior of these mites and their predatory potential. Hence in the present study an attempt was made to understand the impact two different microhabitat conditions such as the natural (outdoor) and the enclosed (polyhouse) on the faunal diversity and species richness of phytoseiid mites.

Materials and methods

Surveys were conducted on economically important plants like vegetables, horticultural plants and medicinal plants in four different sites of Kozhikode district, Kerala, *viz*; namely Kunnathukara (Lat-Lon: 11° 55', 75° 64') and Kurumpoyil (Lat-Lon: 11° 60', 75°14'). Leaf samples (10 nos) of each plants grown in the Kurumpoyil agri-farm house – open field Site (Io), Kurumpoyil agri-farm house – closed field(Polyhouse Site Ic-), Kunnathukara organic-farm house open field (Site IIo, Kunnathukara organic -farm house –closed field (Polyhouse Site IIc)

Were collected and brought to the laboratory in zip lock covers. Each of the collected leaf was screened under a Trinocular Stereo Zoom microscope (NSZ-606-UOC,"LYNX''LM-523621) in the laboratory and the mite specimens were segregated using a camel hair brush and preserved in 70% ethanol. The preserved specimens were dehydrated in alcohol series and slide mounted in Hoyer's medium for subsequent identification. Taxonomic identity of the various species was determined by examining their morphological features under a Trinocular Research microscope ("LYNX" LM-52-4000). Details of the morphological characters of individual species were compared with those of related taxa following relevant literature and identification keys. Confirmation of species was made by seeming help from experts. Photographs and measurements of the various morphological structures of taxonomic importance were taken using a 5MP CMOS HDMI USB 2.0 Camera attached to the microscope with the help of Annotation and Measurement Software. Data recorded on the host plants, population density of mites etc. were tabulated and used for analysing diversity indices. Species richness, evenness and species diversity were estimated by using Shannon Weiner Diversity Index [5]. In order to analyze the most abundant and prevalent phytoseiid species inhabiting in the two varied habitats, the percentage occurrence of individual species was calculated.

Results and Discussion

Phytoseiid mite abundance in polyhouses and open field

During the study, phytoseiid mites could be collected from all plants grown in the open field condition as well as in poly houses in variable numbers. A total of 842 phytoseiid mite specimens representing 10 species belonging to five genera were collected. *Amblyseius* was assigned as the most species rich genus accommodating 50 % of the total species collected. The remaining four genera were represented by a single species each. Table 1 shows the distribution pattern and species diversity of phytoseiid mites on host plants surveyed during the study. Highest densities of phytoseiids could be recorded on *Solanum melongena* and the lowest was on *Syzygium samarangense* grown in open habitat. Host plants also displayed variation with respect to their mite fauna. The maximum number of species (4) was found to inhabit the leaves of the host plant, *Nephelium lappaceum. Litchi chinensis* formed the second in supporting species diversity of mites as it harboured three species of phytoseiids. The species diversity on other host plants in the study were found 2species on *Garcinia mangostan*, *S. melongona*, and *S. lycopersicum*. *Cucurbita pepo S.samarangense* and *Psidium guajova* harboured only a single species of phytoseiid mite.

Table 1: Distribution pattern of phytoseiid mites on plants surveyed during the study

SI No.	Host plants	M1	M2	M3	M4	M5	M6	M7	M8.	M9	M10
1	*Cucurbita pepo* L	--	--	--	--	--	--	--	--	--	++
2	*Syzygium samarangense* (Bllume)	--	+	--	--	--	--	--	--	--	--
3	*Garcinia mangostan* L	--	--	++	++	--	--	--	--	--	--
4	*solanum melongena* L	++	--	+++		--	--	--	--	--	--
5	*Nephelium lappaceum* L		++		+	++	++	--	--	--	--
6	*Litchi chinensis* Sonn	++	--	--				++	++	--	--
7	*Psidium guajava* L		--	--	--	--	--	--	--	++	--
8	*Solanum lycopersicum* L	++		--	++	--	--	--	--	--	--
9	*Capsicum annum* L	++	--	--	--	--	--	--	--	--	--
10	*Vigna unguiculata L.*	--	--	--	++	--	--	--	--	--	--
11	*Abelmoschus esculentus* (L)	++	--	--	--	--	++	--	--	--	--

M1: *P. orientalis*, M2: *A. channabasavannai*, M3: *A. paraarealis*, M4: *A. largoensis*, M5: *A. raorellus*, M6: *A. arealis*, M7: *Typhlodromus* sp., M8: *Phytoscutus* sp., M9: *S. polyatheae*, M10: *S. sukunaensis* (+ and – symbols designate the abundance and absence of phytoseiid mites.)

Out of 10 species recovered, five species *viz*., *Amblyseius channabasavannai*, *A. raorellus*, *A. largoensis* and *A. arealis* were collected from the host plant, *Nephelium lappaceum*. *A. paraarealis* was recognized as the most abundant species (31.47%), followed by *Scapulaseius polyantheae* (11.75%), *A. largoensis* (11.52%) and *A. channabasavannai* (10.8%). The minimum density of population was shown by two species such as *Phytoscutus* sp. (3.91%) and *Typhlodromus* sp. (4.75%) (Table 2; Fig. 2).

Table 2: Percentage proportion of phytoseiid mites on plants

Sl. No.	Name of species	Percentage composition of different species of phytoseiid mites
1	*Amblyseius areialis*	7.48
2	*Amblyseius channabasavannai*	10.8
3	*Amblyseius paraaerialis*	31.47
4	*Amblyseius largoensis*	11.52
5	*Amblyseius raoiellus*	5.7
6	*Paraphytoseius orientalis*	4.27
7	*Scapulaensis sukunaensis*	8.31
8	*Scapulasius polyantheae*	11.75
9	*Phytoscutus sp.*	3.91
10	*Typhlodromus sp.*	4.75

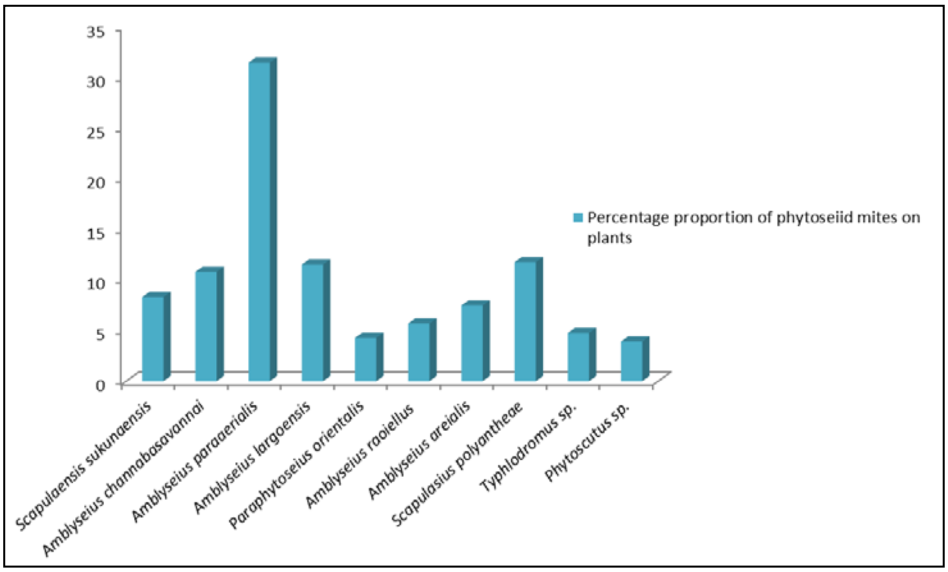

Fig 2: Percentage composition of phytoseiid mites on plants

Results of the present study revealed that the plants growing in open field condition could support the maximum species diversity and population density of mite when compared to those cultivated in polyhouses (Table 3; Fig 3.).

Table 3: Population density of individual Phytoseiid species on plants grown in open and closed Agricultural Ecosystems

Sl. No.	Phytoseiid Species	SiteIo	SiteI c	Site IIo	Site IIc
1	*Amblyseius areialis* (Muma, 1955)	0	0	56	7
2	*Amblyseius channabasavannai* Gupta & Daniel, 1978	20	5	66	0
3	*Amblyseius largoensis (*Muma, 1955)	37	4	53	3
4	*Amblyseius paraaerialis* Muma, 1965	33	4	225	3
5	*Amblyseius raoiellus* Denmart & Muma, 1989	0	0	48	0
6	*Paraphytoseius orientalis* Narayanan et al.,1961	0	0	27	9
7	*Scapulasius polyantheae* (Gupta, 1975)	0	0	99	0
8	*Scapulaensis sukunaensis* Gupta, 1970	70	0	0	0
9	*Typhlodromus* sp.	0	0	40	0
10	*Phytoscutus* sp.	0	0	33	0
Total		160	13	647	22

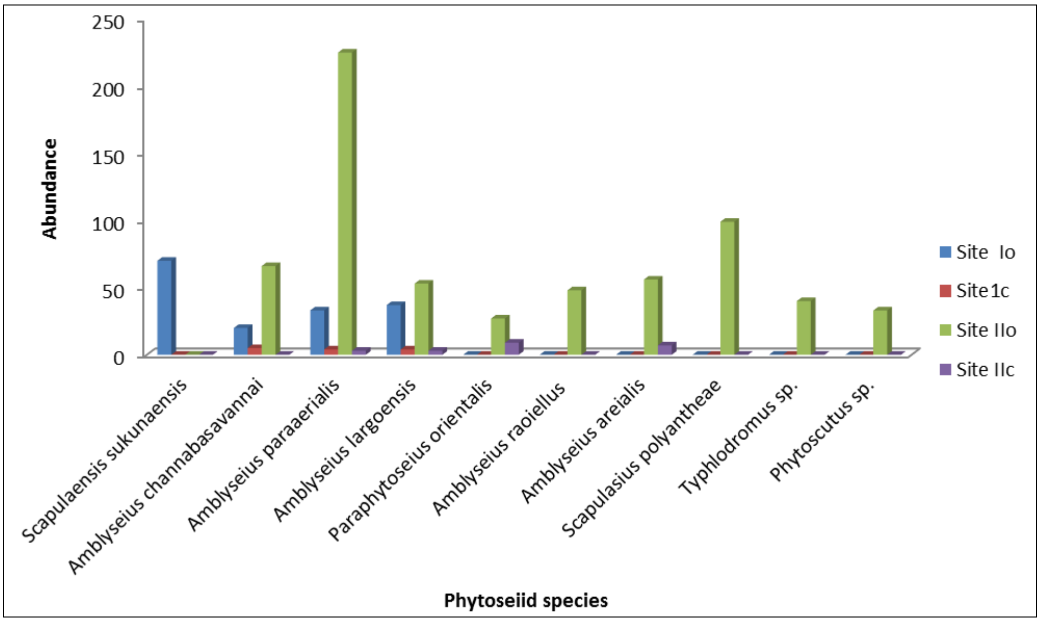

Fig 3: Population density Phytoseiid mite Species on plants grown/cultivated in open and closed habitats

The number of mites were particularly high on plants growing in Kunnathukara Organic Farmhouse (Site IIo) premises (647) followed by Kurumpoyil Farmhouse (Site Io) premises (160). The lowest number of phytoseiid were collected from polyhouses of Kurumpoyil Farmhouse (13), compared to that from the polyhouses at Kunnathukara Organic Farmhouse (22). The difference in the number phytoseiid mites in the open field may be due to the difference in geographical conditions or may be the availability of prey i.e. pests (Pia Parolin *et.al* 2015) [11]. However the higher densities of phytoseiids in these two open field ecosystems showed the natural balance of pest – predator relationship because in these ecosystems the pest populations were found controlled by predators, as the injuries made by the pests were found negligible. This signifies the role of phyoseiid mites as biological control agents in various agricultural ecosystems (Chant, D A. 1985) and important natural enemies of phytophagous mites in IPM strategies on outdoor as well as greenhouse crops (Mc Murtry J A & Croft B A. 1997; Van Lenteren, J C and Woets J 1988) [1, 9, 14]. Plants grown in poly houses at Kunnathukara Organic Farmhouse were sprayed with organic pesticides, and which may be accounted for the recovery lowest number of phytoseiids, during the present study, thereby supporting the earlier finding on the adverse effects of pesticides on the phytoseiid fauna of Europe (Hassen *et al.* 1987 &1988). Moreover, the non-availability or low availability of mite/insect preys on the polyhouse cultivated crops in the initial growth stages of crops also would be delimiting the population build up and replenishment of phytoseiid predators, in poly house conditions The non-availability of diverse types of pests in poly house condition also would hinder the population buildup of these mites (Pia Parolin *et al*).

Biodiversity of Phytoseiid mites in polyhouses and open field

The species diversity of phytoseiid mites in the two habitats (polyhouse condition and outdoor of polyhouses) was calculated during the study, following Shannon-Weiner Diversity index (H') as given below:

$$H' = -\sum [(pi) X \ln (pi)]$$

Where pi is the proportion of total sample represented by species i (Number of individual species i (S) is divided by total number of samples (N)

PI = S/N

The Shannon - Weiner diversity index values calculated for the phytoseiid mites in polyhouses at Kurumpoyil (Site Ic) and Kunnathukara (Site IIc) were 1.6185 and 2.3723 respectively. The diversity index values of the outdoor ecosystems of polyhouses were found higher in Kunnatukara (Site IIo: H' = 1.9535) than at Kurumboyil (Site Io: H' = 1.2858). However, the diversity indices of all the ecosystems showed higher diversity and Kunnathukara Organic Farmhouse showed highest diversity during the survey. (Table 4; Fig. 4).

Table 4: Shannon – Weinner Diversity index and species richness in different Agricultural Ecosystems

Sites	Shannon-Weiner Diversity Index H′=-∑ [(pi) ×ln (pi)]	Species Richness H'/LN(S)	Species Evenness S-1/LN(N)
Site Io	1.2858	3.8029	0.825
Site Ic	1.9535	3.6101	0.0521
Site IIo	1.2734	8.8454	0.3506
Site IIc	0.7301	0.2177	0.21

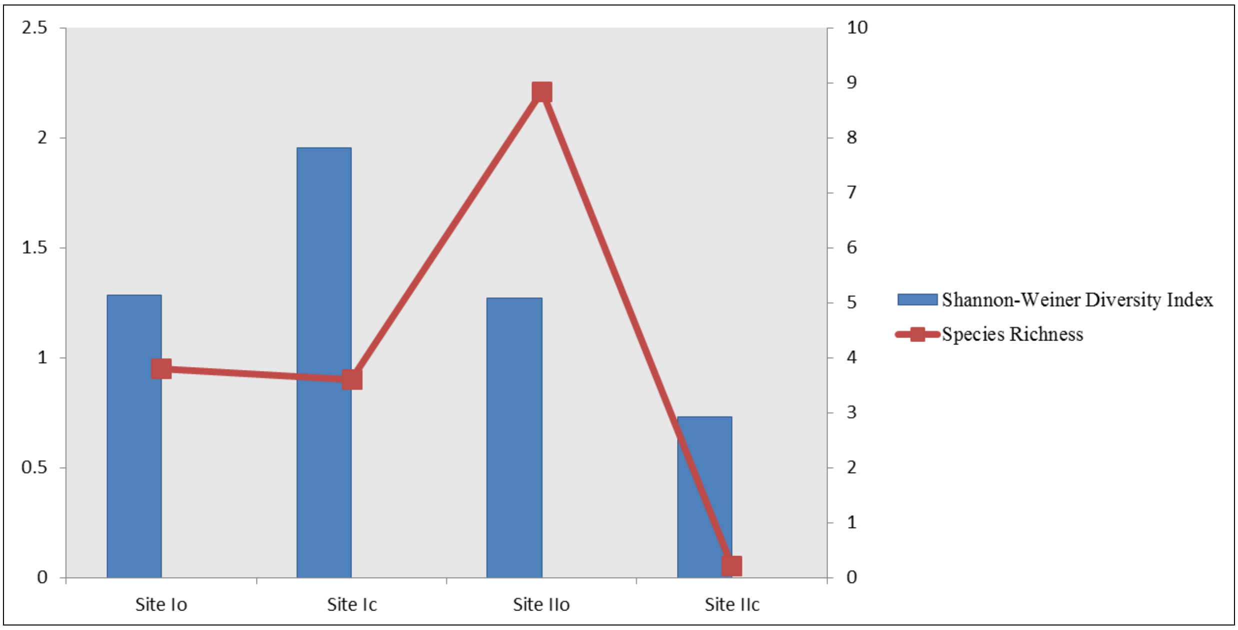

Fig 3: Shannon – Weiner Diversity index and species richness recorded in different sites

Species richness and species evenness of phytoseiid mites in ecosystem under study were calculated as given below
Species Richness = H'/LN (S)
Species Evenness = S-1/LN (N)
Species richness of phytoseiid mites in Site Io, Site Ic, Site IIo, and Site IIc was calculated and the results of which indicated that Kunnathukara outdoor ecosystem had highest species richness (8.84) followed by Site Io (3.80) and Site IIc (3.67). Site IC showed the lowest species richness (2.61) (Table 3, Fig. 2.). On the contrary, Site Io showed highest species evenness (0.8250), followed by site IIo (0.3506) and site IIc (0.21). The lowest value for species evenness was showed by site IIc (Table 3).

Conclusion

This is the first report on statistical analysis of the diversity, abundance and richness of phytoseiid mites in polyhouses and outdoor of polyhouses. The results of the study helped to record a higher diversity of phytoseiid mites on plants grown in open habitats like the outdoor of polyhouses as evidenced in both the sites, than the enclosed habitats available in the polyhouses. The species richness was found far greater in Site IIo than the other sites. *Amblyseius paraarealis* showed higher density in Site IIo where as *Scapulaseius suknaensis* showed higher density in Site Io. The difference in the diversity and abundance of phytoseiid mites in these outdoor conditions would be a reflection of the availability of diverse types of prey and the pesticide-free environmental conditions of open habitats. The reduction in the species diversity and species richness observed in enclosed habitats available in polyhouses would be a reflection of the non-availability of preferred preys, monoculture practice as well as the frequent application of organic pesticides.

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