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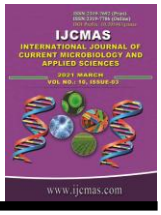

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A Preliminary Study on Diversity and Community Structure of Phytoseiid Mites associated with Medicinal Plants in Selected Locations of Telangana

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A B S T R A C T

In the present study, an investigation was carried out to explore the diversity and community structures of phytoseiid mite fauna associated with medicinal plants in four selected locations *viz.* Ananthagiri, CSIR-CIMAP campus, Kotapally and Eturangaram sanctuary situated in Southern, Northern and Central agroclimatic zones of Telangana. A total of 515 specimens were collected during the present survey belonging to 8 genera and 13 species of which *Euseius alstoniae* (23%), *Amblyseius largoensis* (22%), *Euseius ovalis* (15%), *Euseius astrictus* (6%) and *Phytoseius kapuri* (2%) were the most abundant species. Comparing all the survey locations, Eturangaram sanctuary with natural vegetation of medicinal plants revealed maximum diversity of species whereas scanty vegetation of Ananthagiri hills yielded the least diversity of phytoseiid mites.

Introduction

Telangana state is a newly formed southern region state of India, created by bifurcating Andhra Pradesh state on 2nd June 2014. The total geographical area of Telangana state is 112.07 lakh hectares, of which 23.89 % area is covered by forest and about 43.20 % area is under cultivation (Bhargavi, 2017). Over 2000 species of medicinal plants are found in Telangana state (Singh and Vidyasagar, 2015). Telangana State Medicinal Plant Board has implemented various scheme to encourage the farmers for cultivation of medicinal plants in the farm through subsidies and also train the people for collection of medicinal plants from the forest land for upkeeping the livelihood of the tribal people and helps in marketing the products (Sivaramana and Kumar, 2018). According to the World Health Organization, 80% of the population in the developing countries depends upon the traditional and

herbal medicines in their primary healthcare (Pramanik, 2004). Indeed, several modern drugs are manufactured from phytochemicals extracted from plants with medicinal importance. Healthy plant material is therefore essential for maintaining product quality. However, both quality and quantity are adversely affected by the damage of phytophagous insect and mite pests and diseases during their growth and development.

The mites belonging to the family Phytoseiidae (Mesostigmata) and Cheyletidae, Cunaxidae, Stigmaeidae, Bdellidae, Tydeidae, and Anystidae (Prostigmata) are plants inhabiting pro-active predators to soft-bodied insects and phytophagous mite pests in agri-horticultural crops all over the world. Among the entire predatory mite group, phytoseiids are the most important and commercially exploited owing to their high searching capacity, good adaptability to a wide environmental condition, short life span (1week approx.) and high multiplication capability (40-60 off-springs per female) (Gerson *et al.,* 2003). Under the vision of sustainable farming, these predators can be utilised in the biological control and integrated pest management strategies against different crop pests. Therefore, it is utterly important to know about the diversity of various phytoseiid mite species to employ effective pest management strategies for cultivated medicinal crops. Till now the family Phytoseiidae contains more than 2,400 species worldwide (Demite *et al.,* 2018) and every year new species are being added to this list. Faunistic studies on Phytoseiidae of the country have been explored since the 1960s. More than 235 species of Phytoseiidae are described and reported from India (Karmakar and Gupta, 2014; Pramanik and Karmakar, 2016; Karmakar *et al.,* 2017 and Karmakar and Bhowmik, 2018) of which only a few species has been reported to be associated with medicinal plants so far (Lahiri *et al.,* 2004; Gupta and Karmakar, 2011 and Haneef and Sadanandan 2013). Due to insufficient information available concerning phytoseiid mite fauna associated with medicinal plants in the state of Telangana, the present investigation was carried out to explore the diversity of phytoseiid mite complex on medicinal plants found in selected locations of this state.

Materials and Methods

Study area

Locations for collecting phytoseiid mites associated with medicinal plants from the three different agro-climatic zones of Telangana were nominated based on the availability of required vegetation and also because these locations represent overall agro-climatic features of the respective zones. Kotapally from Northern Telangana, Eturangaram Sanctuary from Central Telangana, Ananthagiri and CSIR-CIMAP from Southern Telangana were selected for the current investigation (Figure 1). Edagatta forest and nearby localities ($18^0$55’40”N, $79^0$49’12”E; $18^0$56’1”N,$79^0$48’53”E; $18^0$55’58”N,$79^0$49’28”E) in Kotapally; forest areas near Warangal- Eturangaram road and Burgampadu-Eturangaram road ($18^0$18’31”N, $80^0$25’25”E $18^0$18’57”N, $80^0$25’1”E $18^0$18’20”N, $80^0$24’40”E) in Eturangaram sanctuary; vegetations near Vikarabad-Tandur road and birding site ($17^0$18’42”N, $77^0$51’5”E; $17^0$18’50”N, $77^0$51’58”E) of Ananthagiri hills forest and medicinal plant garden of CSIR-CIMAP ($17^0$25’34”N, $78^0$34’45”E) were selected to collect the specimens of phytoseiid mites during the present survey.

Collection and preservation of specimens

The phytoseiid mite fauna harbouring on different species of medicinal plants as well as medicinally important forest plants were

examined by making extensive surveys covering different locations of Telangana province during February 2020. Phytoseiid mites are generally bigger in size and fast-moving in nature.

They were collected directly from the plant with the help of fine camel hairbrush (size 000) and then preserved in 70% alcohol until permanent slides were prepared. Besides, a direct beating method was adopted *i.e.,* simply beating the plant parts over black cardboard and the dislodged mites were collected by using a single hairbrush.

The mite specimens were preserved in a separate small plastic vial containing 70% alcohol mentioning the name of the host and the location. Besides the targeted phytoseiid fauna, the associated phytophagous mite and soft bodied insects were also collected and identified as potential prey for documented phytoseiid predators though direct feeding of these prey species was not observed during present investigation.

Identification of specimens

The specimens were brought to the Acarology laboratory (All India Network Project on Agricultural Acarology), Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, West Bengal. The collected mite specimens were poured in a cavity block and mounted on modified Berlese's medium for identification**.** Then the slides were dried in an oven at 40^0-45^0 C for 7 days.

The mites were examined with a phase and differential interference contrast microscope (BX 53, Olympus) and the phytoseiid species were identified following the keys provided by Chant & McMurty (2007). The specimens collected for the present study are deposited in Acarology laboratory of the same institute. Type specimens of the collected species are presented in plate 1.

Statistical analysis

To understand the diversity and community structure of different phytoseiid mite species in selected locations the number of specimens for each species was enumerated reflecting the species richness (S) and the following diversity and evenness indices were calculated based on the formulae provided by Shannon-Weiner (1963)and Simpson (1949):

Shannon's diversity index (H)
$= -\sum_{i=1}^{s} p_i \ln p_i;$

where the *p* is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), ln is the natural log, Σ is the sum of the calculations, and s is the number of species. The effective number of species (ENS) of each location was calculated taking the exponential of H.

Simpson's index (D)
$= 1-\frac{N(N-1)}{\sum_{i=1}^{s} n(n-1)};$

where N stands for the total number of individuals in a community and n stands for the number of individuals of a particular species. Species evenness was calculated from Pielou's evenness index (E)

Pielou's evenness index (E)
$= \frac{H}{\ln(s)};$

where H is Shannon's diversity index and s is the total number of species in the surveyed area (Pielou, 1975). The coefficient of similarity between the surveyed locations was estimated based on the Sorenson's coefficient (CC)

Sorenson's coefficient (CC)
$= \frac{2C}{S1+S2}$;

Where C is the number of species the two communities have in common, S1 is the total number of species found in community 1, and S2 is the total number of species found in community 2 (Sorenson, 1957).

Results and Discussion

A total of 515 specimens of Phytoseiid mites belonging to 8 genera and 13 species were collected from the natural and cultivated vegetations of medicinal plants in Ananthagiri, Kotapally, CSIR-CIMAP and Eturangaram sanctuary located in different agroclimatic zones of Telangana (Table 1). Diversity and proportional abundance of the phytoseiid species in selected locations are presented in figure 2. The phytoseiid community structures of these areas are furnished in Table 2 and 3.

Sampling in the Eturangaram sanctuary revealed highest species richness (S=9) among the four survey locations followed by Kotapally and CSIR-CIMAP with S=8 and Ananthagiri with S=7.

Also, the Eturangaram sanctuary had the highest diversity of Phytoseiid species in terms of H=1.76 with moderate species evenness of 0.80 and 6 effective number of species but lowest D=0.76 which reflects an environment highly favourable for few species while not so favourable for others. *Amblyseius largoensis* was the dominant species (40%) in this region followed by *Euseius alstroniae* (21%) and *Euseius ovalis* (15%). Surprisingly, 4 species of phytoseiids *viz. Asperoseius jujubae*, *Phytoseius jujubae*, *Neoseiulus longispinosus* and *Paraphytoseius orientalis* were found only in Eturangaram sanctuary among the surveyed locations. Despite having similar species richness, Kotapally had higher diversity in terms of H=1.70, ENS=8, D=0.80 and E=0.83 in comparison to the CSIR-CIMAP which exhibited the indices as 1.65, 5, 0.79 and 0.79 respectively. Compared to the natural vegetation of Kotapally, medicinal plants sampled in the campus of CSIR-CIMAP are artificially maintained in agroecosystems which may lead to the reduction of species diversity in this location.

The number of plants surveyed was also less in CSIR-CIMAP campus than the surveyed area of Kotapally which may be another reason for reduced diversity in this area.*Amblyseius largoensis* and *Typhlodromips syzygii* were the dominant species (25% each) in Kotapally followed by *Amblyseius brachycalyx* (20%) and *Euseius alstoniae* (15%). Present survey in CSIR-CIMAP campus revealed the highest diversity of *Euseius alstoniae* (33%) followed by *Euseius ovalis* (25%) and *Euseius astrictus* (19%). Surprisingly, a single specimen of *Euseius sundarbanensis* was discovered from CIMAP which was not reported earlier from Southern India.

Community structure of Phytoseiid species in Ananthagiri hills revealed lowest species diversity in terms of H=1.60, ENS=5, D=0.77 and E=0.82 probably due to less vegetation in the surveyed areas. *Euseius ovalis* (30%) was the predominant species in this region followed by *Typhlodromips syzygii* (28%) and *Euseius alstoniae* (24%).

The Sorenson's coefficient revealed extremely high community overlap or similarity between the species complex of Ananthagiri and Kotapally followed by a moderately high overlap of species complex between Kotapally and CSIR-CIMAP.

At the same time, the species complex of Eturangaram sanctuary when compared with Kotapally, Ananthagiri and CSIR-CIMAP exhibited the lowest coefficient reflecting very less overlap between these communities.

Table.1 Diversity of Phytoseiid mite fauna associated with different medicinal plants in selected locations of Telangana

Location	Name of host plants	Name of Phytoseiid species	Potential prey found during survey	Number of collected specimens of Phytoseiid mites
Ananthagiri (Southern Telangana)	*Millettia pinnata* *Vachellianilotica* *Ricinus communis* *Alstoniascholaris* *Tabernaemonta nadivaricata* *Bougainvillea glabra* *Nerium oleander* *Anacardium occidentale* *Cocos lucifera* *Earleaf acacia* *Tecoma stans* *Azadirachta indica* *Limoniaacidissima* *Sapindusmukorossi* *Earleaf acacia* *Senna auriculata* *Catharanthus roseus*	*Amblyseius brachycalyx* Karmakar, Bhowmik & Sherpa, 2017	*Bemisia tabaci*	3
		Amblyseius largoensis (Muma, 1955)	*Raoiella indica*	4
		Euseius alstroniae (Gupta, 1975)	*Eriophyid sp.*	23
		Euseius astrictus Karmakar & Bhowmik, 2018	*Eriophyid sp.*	9
		Euseius ovalis (Evans, 1953)	*Tetranychusurticae, Polyphagotarsonemus latus*	29
		Phytoseius kapuri (Gupta, 1969b)	*Tetranychus urticae*	2
		Typhlodromips syzygii (Gupta, 1975)	*Tetranychus macfarlanei*	27
Kotapally (Northern Telangana)	*Phoenix dactylifera* *Santalum album* *Mangifera indica* *Ziziphus mauritiana* *Ficus racemosa* *Holarrhenapubescens* *Ocimum sanctum* *Manilkara zapota* *Citrus aurantifolia* *Moringa oleifera* *Mangifera indica* *Annona reticulata* *Psidium guajava* *Carica papaya* *Senna auriculata* *Terminalia arjuna* *Millettia pinnata* *Emblica officinalis* *Manilkara hexandra* *Butea monosperma* *Cyperus rotundus*	*Amblyseius brachycalyx* Karmakar, Bhowmik & Sherpa, 2017	*Polyphagotarsonemus latus, Tetranychus urticae*	44
		Amblyseius largoensis (Muma, 1955)	*Tetranychus urticae, Tetranychus macfarlanei, Eriophyid sp.*	54
		Euseius alstroniae (Gupta, 1975)	*Polyphagotarsonemus latus, Bemisia tabaci*	42
		Euseius astrictus Karmakar & Bhowmik, 2018	-	4
		Euseius ovalis (Evans, 1953)	*Tetranychus macfarlanei*	12
		Phytoseius kapuri (Gupta, 1969b)	-	3
		Typhlodromips syzygii (Gupta, 1975)	*Polyphagotarsonemus latus Eriophyid sp.*	53
		Typhlodromus	-	4

	Ocimimamericanum *Ocimumbasillicum* *Morus alba* *Cassia fistula* *Cleistanthuscollinus* *Hibiscus rosa-sinensis* *Psidium cattleyanum* *Ficus religiosa* *Alangiumsalviifolium* *Ficus religiosa*	*(Anthoseius) sp.*		
CIMAP (Southern Telengana)	*Artocarpus heterophyllus* *Nycthanthesarbor-tristis* *Bougainvillea glabra* *Calophylluminophyllum* *Monoonlongifolium* *Psidium guajava* *Simarouba glauca* *Sapindusmukorossi* *Leucaena leucocephala* *Murrayakoenigii* *Azadirachta indica* *Withaniasomnifera* *Aegle marmelos* *Mimusopselengi* *Curcuma longa* *Justicia adhatoda* *Bombax ceiba* *Melia dubia* *Ocimum sanctum* *Tamarindus indica*	*Amblyseius brachycalyx* Karmakar, Bhowmik & Sherpa, 2017	*Tetranychus ludeni*	5
		Amblyseius largoensis (Muma, 1955)	*Polyphagotarsonemus latus*	1
		Euseius alstroniae (Gupta, 1975)	*Eriophyid sp.*	22
		Euseius astrictus Karmakar & Bhowmik, 2018	*Bemisia tabaci*	13
		Euseius ovalis (Evans, 1953)	*Polyphagotarsonemus latus*	17
		Euseius sundarbanensis Karmakar & Bhowmik, 2018	-	1
		Phytoseius kapuri (Gupta, 1969b)	*Tetranychus urticae*	1
		Typhlodromus (Anthoseius) sp.	*Polyphagotarsonemus latus*	7
Eturangaram sanctuary (Central Telengana)	*Ricinus communis* *Bougainvillea glabra* *Tecoma stans* *Spathodeacampanulata* *Limoniaacidissima* *Earleaf acacia* *Catharanthus roseus* *Mangifera indica* *Ziziphus mauritiana* *Manilkara zapota* *Moringa oleifera* *Psidium guajava* *Senna auriculata*	*Amblyseius largoensis* (Muma, 1955)	*Tetranychus ludeni*	54
		Asperoseius jujubae Karmakar & Bhowmik, 2018	-	6
		Euseius alstroniae (Gupta, 1975)	*Polyphagotarsonemus latus*, *Eriophyid sp.*	28
		Euseius astrictus Karmakar & Bhowmik, 2018	-	3
		Euseius ovalis (Evans, 1953)	*Tetranychus urticae*	20

	Butea monosperma *Morus alba* *Cassia fistula* *Hibiscus rosa-sinensis* *Monoonlongifolium* *Murrayakoenigii* *Azadirachta indica* *Ocimum sanctum* *Carica papaya*	*Paraphytoseius orientalis* (Narayanan, Kaur &Ghai, 1960)	*Polyphagotarsonemus latus*	5
		Phytoseius kapuri (Gupta, 1969)	*Eriophyid sp.*	4
		Phytoseius jujubae (Gupta, 1977)	-	5
		Neoseiulus longispinosus	*Tetranychus ludeni*	10

Table.2 Community structure of Phytoseiid mite species associated with Medicinal plants in selected locations of Telangana

Sampled communities	Species richness (S)	Shannon Index (H)	ENS	Simpson's Index (D)	Pielou's Index (E)
Ananthagiri (C1)	7	1.60	5	0.77	0.82
Kotapally (C2)	8	1.70	8	0.80	0.83
CSIR-CIMAP (C3)	8	1.65	5	0.79	0.79
Eturangaram sanctuary(C4)	9	1.76	6	0.76	0.80

Fig.1 Survey locations in three agroclimatic zones of Telangana (Map modified from https://pjtsau.edu.in/research.html)

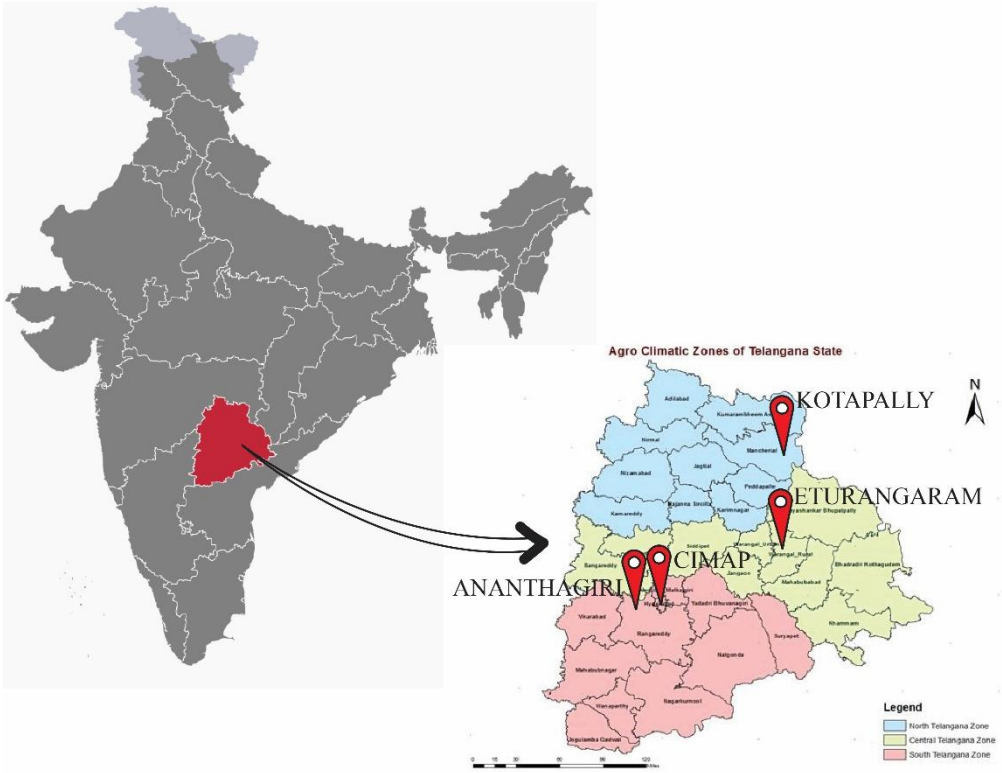


Table.3 Species overlap between selected Phytoseiid communities associated with medicinal plants of Telangana

C1C2	C1C3	C1C4	C2C3	C2C4	C3C4
0.93	0.8	0.63	0.87	0.60	0.60

Fig.2 Diversity and proportional abundance of Phytoseiid species in Telangana

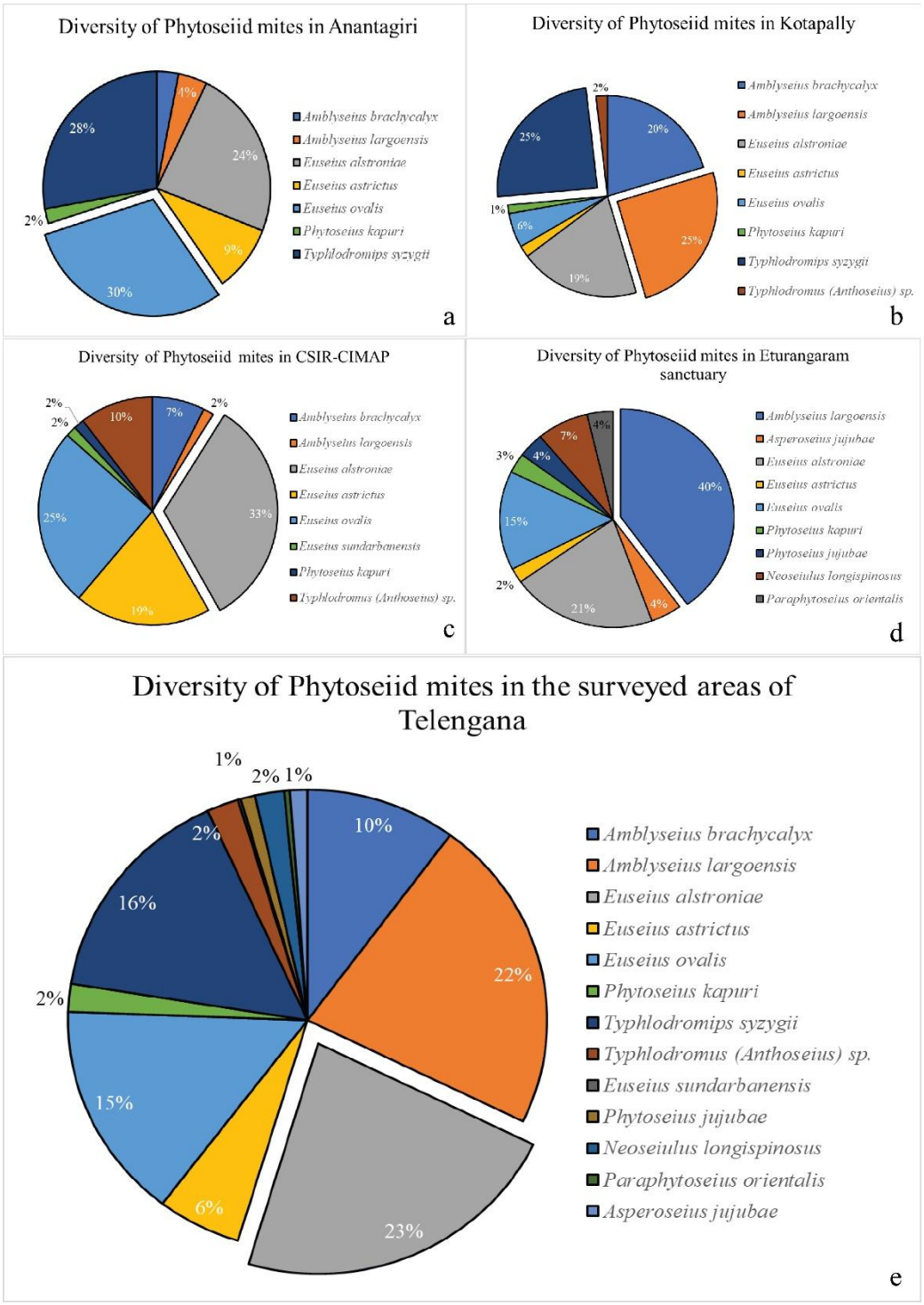
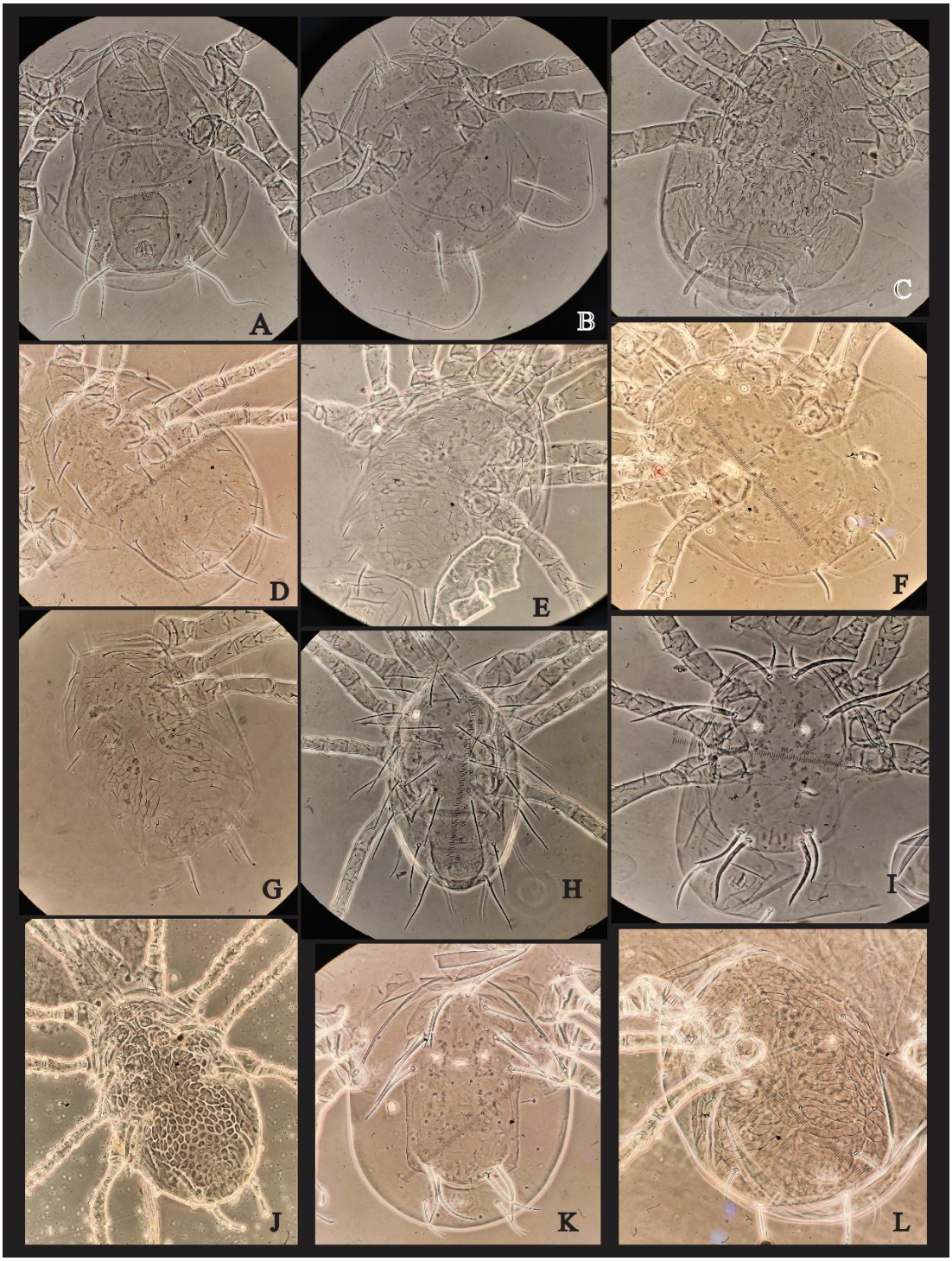


Plate.1 Representatives of the phytoseiid fauna collected from the medicinal plants of Telangana: A. *Amblyseius brachycalyx*, B. *Amblyseiuslargoensis*, C. *Asperoseius jujubae*, D. *Euseius alstroniae*, E. *Euseius astrictus*, F. *Euseius ovalis*, G. *Euseiussundar banensis*, H. *Neoseiulus longispinosus*, I. *Paraphytoseius orientalis*, J. *Phytoseius jujubae*, K. *Phytoseius kapuri*, L. *Typhlodromips syzygii*



In the present investigation, *Amblyseius largoensis*, *Euseius alstoniae*, *Euseius ovalis*, *Euseius astrictus* and *Phytoseius kapuri* were found as the most common species comprising respectively 22%, 23%, 15%, 6% and 2% of the total specimens which reflects a considerably high abundance of these species across all the selected locations of Telangana. Among the other species, *Typhlodromips syzygii* (16%) collected from Ananthagiri and Kotapally and *Amblyseius brachycalyx* (10%) collected from Ananthagiri, Kotapally and CSIR-CIMAP exhibited a moderate abundance. These predatory mites were found to be associated with number of herbivore mite and insect species such as *Polyphagotarsonemus latus*, *Raoiella indica*, *Tetranychus spp*. *Eriophyid species*, *Bemisia tabaci* etc. but exact predator-prey relationship was not established. *Tetranychus spp.* and *Polyphagotarsonemus latus* were found to be most abundant and potential prey species during this survey.

The present study reflects an overall diversity and abundance of phytoseiid mites associated with different medicinal plants of Telangana. The natural vegetations of Eturangaram forest in Central Telangana zone reflected the highest diversity and species richness followed by the natural vegetations of Kotapally in Northern Telangana Zone. The outcomes of this investigation will serve as one of the most important references for future faunistic studies of phytoseiid mites in Telangana. However, further survey and sampling in these regions are required to explore and describe the unknown and rediscover the known species of phytoseiid mites associated with medicinal and other economically important plants and predator prey relationship with associated phytophagous mite and insect species requires to be thoroughly investigated for formulating effective biological control modules.

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