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A note on predatory mites on medicinal plants in South Bengal with results on their predator-prey interaction

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Abstract
The present paper reports the occurrence of predatory mites on medicinal plants from coastal region of West Bengal, India on the basis of collection made during 2014-2015. As many as 36 species belonging to 15 genera and 7 families under 3 orders are reported. The species which were found to be most the promising phytoseiid predators seen during the present study were *Amblyseius largoensis*, *Neoseiulus longispinosus*, *Euseius finlandicus*, *Euseius alstoniae* and *Euseius coccineae*. All these mostly fed upon various stages of Tetranychid mites in the field. To conserve those promising predators attempts are being made to find out suitable strategy and also doing mass multiplication of *Neoseiulus longispinosus*, one of the most dominating predators ascertaining their potentiality as bio-control agents. This paper discusses all these aspects in details for utilizing predatory mites in bio-control programme of *Tetranychus macfarlanei*.

Keywords: diversity study, bio-control, *T. macfarlanei*, predatory mite, medicinal plant, Southern West Bengal, India

Introduction
Medicinal plants are receiving global importance because of their manifold uses like preparation of herbal drugs as well as in preparation of nutraceuticals, colouring, flavouring, agents, phytopesticedes etc [1]. These plants are often those attacked by pests both insects and mites and often do noticeable damage causing qualitative and quantitative loss of the active ingredients used in preparation of herbal drugs. Unlike other agricultural crops, chemical pesticides not sprayed for control of pests due to obvious reasons and therefore alternative strategy needs to be found out for pest management purpose. In order to maintain the quality of active ingredients of medicinal plants, and on the other hand to avoid use of chemical pesticides, biological control with predatory mites will be effective alternative. The first task in that direction is to conduct surveys and document the potential predators to conserve and utilize those effectively. The present paper highlights the results of surveys for predatory mites in coastal region of South Bengal, a predator prey interaction in respect of *Neoseiulus longispinosus* with *Tetranychus macfarlanei* infesting *Withania somnifera* under laboratory condition.

Materials and Methods
For Surveys and identification
Surveys were conducted for the predatory mites of medicinal plants during Dec 2014-Nov 2015 at different localities of Coastal region of South Bengal (such as Moyna, Tamluk, Haldia, Malancha, Basanti, Ghusiara, God Khali, Gosaba, Narendrapur, Kakdwip, Bok khali, Sagar Island, etc) as depicted**.** Leaves of different medicinal plants were examined in the field itself under 20X lens and predatory mites were collected with a fine brush moistened with 70% alcohol. The mounting was done with modified Hoyer's medium. While making collection in the field, observations were recorded whether they were feeding on prey mite or found associated.

For Mass production
A preliminary attempt was made on mass production of *Neoseiulus longispinosus* on *Withania somnifera* using *Tetranychus macfarlanei* as prey using conventional method [2].

Harvesting was done after 20 days of predator release and the total number of predators harvested was recorded (Table- 2).

For predator – prey interaction study

This experiment was done following conventional method of Helle and Sabelis [2] using potted plants. The experiment on predator -prey interaction was conducted in a screen house for evaluating predatory efficiency of *N. longispinosus* on *T. macfarlanei* in potted *Withania somnifera* plant. 4 ratios of predator : prey mites were used viz. 1:10, 1:15, 1:20 and 1:25, and a control with no predatory mite was kept. Observations towards Predator prey interaction were recorded 1,4,8,12,16 days after predator release. Similar observations were recorded for control treatment also. Temperature ranged between 27.5º -30 ºC, with 60-70% RH (Table- 3).

Result and Discussion

Surveys and identification

During the present investigation 36 species belonging to 15 genera and 7 families under 3 orders were recorded (Table-1). These belong to Phytoseiidae- 19 species under 7 genera, Ascidae - 1 species, Stigmaeidae - 6 species under 1genus, Cunaxidae- 3 species under 1 genus, Bdellidae- 1 species, Tydeidae- 5 species under 3 genera and Acaridae- 1 species. Along with listing of mites, the plant habitats on which those were recorded and the associated prey, if any, were indicated in the remarks column (Table-1). Among these, the species which were abundantly seen on medicinal plants and had shown potentiality in doing a good job of feeding mostly upon Tetranychidae and Tarsonemidae mites are: *Paraphytoseius multidentatus* on *Polyphagotarsenemus latus* infesting *Ocimum gratissimum*, *Agistimus gambli* feeding on *Eutetranychus orientalis* infesting *Rauvolfia tetraphylla*, *Amblyseius largoensis* on *Tetranychus neocaledonicus* on *Ricinus communis*, *Agistemus fleschneri* on *Polyphagotarsonemus latus* infesting *Ocimum tenuiflorum*, *Pronematus fleschneri* feeding upon *Eutetranychus orientalis* on *Ocimum sanctum*. The promising phytoseiid predators were *Amblyseius largoensis*, *Neoseiulus longispinosus*, *Euseius finlandicus*, *Euseius alstoniae* and *Euseius coccineae*. All these mostly fed upon various stages of Tetranychid mites.

Several workers [1, 3-5, 7-15] studied the diversity of predatory mites on medicinal plants as well as agri-horticultural crops at different locations in India and abroad but none of them surveyed as extensively as has been done now at the coastal areas of West Bengal.

Mass production

In case of mass multiplication, it was found that at a release of 20 prey mites with 10 predators, the harvested predatory mites was 160 & the corresponding figure for 30 prey mites, the harvested predator was 193 (Table- 2). Moreover, the number of predator mites harvested at different ratios of prey: predator are given in (Table-3). The mean number of predatory mites harvested after 20 days was 192.53 and 278.16 with the ratios of 20 prey mites: 3 predatory mites and 30 prey mites: 5 predatory mites, respectively. The result is of preliminary nature and further experimentation is going on with different other predators- prey ratios.

Works on the rearing and mass production of different predatory mites were done by several workers worldwide such as Fournier *et al.* [16] studied on rearing and mass production of *Phytoseiulus persimilis* Athias-Henriot on *Tetranychus urticae* Koch; Hegde and Patil, [17] worked on mass rearing of *Amblyseius longispinosus* (Evans) on Cotton Red Spider Mite, *Tetranychus macfarlanei* Baker and Pritchard ; Mallik *et al.* [18] worked on the Mass production of predators, *Amblyseius longispinosus*; Vaidya, [19] studied on management of Tetranychus urticae Koch (Acari: Tetranychidae) on rose in poly house conditions using *Amblyseius longispinosus* (Evans) ; Jayasinghe and Mallik, [20] studied on the mass production of *Neoseiulus longispinosus*, a phytoseiid predator of spider mites *Tetranuchus urticae* Koch under greenhouses condition as well as on field grown crops; Khanamani *et al.* [21] reared the predatory mite *Neoseiulus californicus* with different artificial diets under laboratory conditions.

For predator – prey interaction study

In case of predator prey interaction, it was observed that noticeable reduction took place in population of *T. macfarlanei* at all ratios of predator release. The mean percentage reduction of prey mite after different intervals were 10.58, 8.87, 7.67 and 5.70 with the release of 10, 15, 20 and 25 predators/ plant respectively (Table- 4). Release of 40 mites / plant was the best which caused mean reduction of population of prey mite as much as 5.70% (Table- 4). On the contrary, there was gradual increase in the population of prey mite as much as the time elapsed continued till 8 days but thereafter it started declining as because the prey mite population also gradually decreased (Table- 4). Hence, release of 25 predator per plant will be effective for control of *T. macfarlanei* on *Withania somnifera.*

Some of the relevant works are Walzer *et al.* [22] who worked on the population dynamics of interacting predatory mites, *Phytoseiulus persimilis* and *Neoseiulus californicus*, held on detached bean leaves. Schausberger and Walzer., [23] studied Combined versus single species release of predaceous mites: predator–predator interactions and pest suppression. Greco *et al.* [24] studied Neoseiulus californicus as a potential control agent of Tetranychus urticae and effect of pest/predator ratio on pest abundance on strawberry. Hatherly *et al.* [25] observed the Intraguild predation and feeding preferences in three species of phytoseiid mite used for biological control. Cakmak *et al.* [26] studied Intraguild interactions between the predatory mites *Neoseiulus californicus* and *Phytoseiulus persimilis.* Farazmand *et al.* [27] observed the predation preference of *Neoseiulus californicus and Typhlodromus bagdasarjani on heterospecific phytoseiid and Scolothrips longicornis in presence and absence of Tetranychus urticae.* Ali *et al.* [28] observed prey consumption and functional response of a phytoseiid predator, *Neoseiulus womersleyi*, feeding on spider mite, *Tetranychus macfarlanei*. Ulla and Gotoh, [29] studied on the life-history parameters of *N. womersleyi* using different spider mites (*Tetranychus kanzawai*, *T. macfarlanei*, *T. merganser*, *T. truncatus* and *Oligonychus biharensis*) as prey and show that *N. womersleyi* can be used as a highly efficient biological control agent of spider mites. Adar *et al.*, [30] studied on the plant feeding phytoseiid predators for pest control.

Table 1: A list of predatory mites of Medicinal Plants in South Bengal

Mite species		Host Plants	Remarks
Predatory	**Prey**		
I. Order : Prostigmata **i. Family: Bdellidae** **Species:** 1. *Bdellodes angustifolius* Gupta **ii. Family: Cunaxidae** **Species:** 1. *Cunaxa mangiferae* Gupta 2. *Cunaxa setirostris* (Hermann) 3. *Cunaxa capreolus* (Berlese) **v. Family: Stigmaeidae** **Species:** 1. *Agistemus hystrix* Gupta 2. *Agistemus terminalis* (Quayle) 3. *Agistemus edulis* Gupta 4. *Agistemus gamli* Gupta 5.*Agistemus obscura* Gupta 6.*Agistemus flechneri* Summers **iv. Family: Tydeidae** **Species:** 1. *Parapronematus cameliae* Gupta 2. *Parapronematus murshidabadensis* Gupta 3.*Pronematus fleschneri* Baker 4. *Pronematus sextoni* Baker 5. *Tydeus wallachi* Gupta & Chatterjee	*Tetranychus macfarlanei* Baker and Pritchard *Brevipalpus* sp. *Brevipalpus karachiensis* Chaudhri *Tarsonemus* sp. *Brevipalpus obovatus* Donnadieu *Tetranychus ludeni* Zacher *Eutetranychus orientalis* (Klein) *Brevipalpus phoenicis* (Geijskes) *Polyphagostarsonemus latus* Banks *Tetranychus* sp. *Brevipalpus mitrofanovi* (Pegazzano) *Eutetranychus orientalis* (Klein) *Brevipalpus recki* Livschitz & Mitrofanov *Brevipalpus dipholosi* De Leon	*Terminalia catappa* *Ficus carica* *Hibiscus rosa-sinensis* *Justicia adhatoda* *Ricinus communis* *Citrus* sp. *Ocimum gratisimum* *Rauvolfia tetraphylla* *Ficus carica* *Ocimum tenuiflorum* *Moringa oleifera* *Lawsonia inermis* *Ocimum sanctum* *Nyctanthes arbor-tristis* *Ocimum gratissimum*	Occasionally encountered, no feeding observed. Good predator of *Tetranychus macfarlanei*, abundantly found. Associated with *Brevipalpus* colony, no feeding. Regularly encountered infestation of *B. karachiensis* and found feeding upon eggs and immature. Found in association with *Tarsonemus* sp., no feeding. It was found voraciously feeding upon eggs and nymphal stages of *Brevipalpus* sp. Active predator of *T. ludeni*,, especially on eggs. Found in colony of *Eutetranychus orientalis*, no feeding Occasionally recorded, no feeding. Associated with *P. latus*, found feeding on all stages. Associated with *Brevipalpus* sp. colony, feeding not observed. Occasionally encountered, no feeding observed. Good predator of *E. orientalis*, specially on immature. Associated with *Brevipalpus* sp. colony, no feeding. Associated with *Brevipalpus* sp. colony, no feeding.
II. Order : Mesostigmata **i. Family: Phytoseiidae** **Species:** 1. *Amblysieus largoensis* (Muma) 2.*Amblysieus* herbicolus (Chant) 3. *Amblysieus mcmurtryi* Muma 4.*Amblysieus paraaerialis* Muma 5.*Eusieus finlandicus* (Oudemans) 6. *Euseius alstoniae* (Gupta) 7. *Eusieus ovalis* (Evans) 8. *Euseius coccineae* (Gupta) 9. *Euseius eucalypti* (Gupta) 10. *Euseius prasadi* Chant & Mc Murtry 11. *Neoseiulus longispinosus* (Evans) 12. *Neoseiulus suknaensis*(Gupta)	*Tetranychus neocaledonicus* Andre *Brevipalpus* sp. *Brevipalpus* sp. *Tetranychus urticae* Koch *Brevipalpus* sp. *Panonychus citri* (McGregor) *Panonychus citri* (McGregor) ---------- *Tetranychus macfarlanei* Baker & Prichard *Brevipalpus* sp. *T. macfarlanei/ T. urticae /T. neocaledonicus* *Tetranychus hypogeae* Gupta	*Ricinus communis* *Ficus carica* *Aegle marmelos* *Shorea robusta* *Nyctanthes arbor-tristis* *Carica papaya* *Carica papaya* *Magnolia champaca* *Ficus carica* *Ricinus communis* *Mangifera indica/ F. carica* *Abelmoschus moschatus*	Regularly encountered with *T. neocaledonicus*, a good predator of all stages. Occasionally encountered, no importance found. Good predator of *Brevipalpus* sp.specially on immature. Associated with *Tetranychus* colony, feeding not observed. Good predator of all stages of *Brevipalpus* sp. Dominantly associated with *Panonychus citri*, good predator specially on immatures. Good predator of *P. citri*, abundantly available. Predation not observed. Found associated with colony of *T. macfarlanae*, no feeding observed. Found associated with colony of *Brevipalpus* sp., feeding not observed. Very efficient predator of *Tetranychus* spp., mostly on eggs and immature stages. Abundantly available often in association with *Tetranychus* sp., feeder of immature.

Mite species		Host Plants	Remarks
Predatory	**Prey**		
II. Order : Mesostigmata **i. Family: Phytoseiidae** **Species:** 13.*Paraphytoseius orientalis* (Narayanan &Kaur) 14. *Paraphytoseius scleroticus* (Gupta & Ray) 15.*Phytoseius kapuri* Gupta 16.*Phytoseius minutes* Narayanan *et al* *17.Phytoseius wainsteini* Gupta 18. *Phytoscutella salebrosus* (Chant) 19. *Typhlodromips syzygii* (Gupta) **ii. Family: Ascidae** **Species:** 1. *Melichares* sp.	*P. latus* ---------- *Oligonychus martensis* Meyer *Schizotetranychus baltazari* Rimando *Brevipalpus mitrofanovi* (Pegazzano) ---------- *Schizotetranychus* sp. *P. latus*	*Ocimum gratisimum* *Abelmoschus moschatus* *Aegle marmelos* *Mikania micrantha* *Passiflora caerulea* *Hibiscus rosa-sinensis* *Megathyrsus maximus* *Ricinus communis*	Found associated with *P. latus*, found feeding on all stages. No feeding observed. Found associated with colony of *Oligonychus martensis*, predatory importance not noticed. Recorded from colony of *Schizotetranychus baltazari*, egg feeders. Found associated with colony of *B. mitrofanovi*, no feeding observed. Occasionally recorded. Abundantly available mostly in association with *Schizotetranychus* sp. Good predator of *P. latus*, especially on eggs.
III. Order : Astigmata **i. Family: Acaridae**	*Tetranychus macfarlanei* Baker &	*Justicia adhatoda*	Occasionally encountered with *T. macfarlanei*, found feeding on eggs.

Species: 1. *Tyrophagus longior* (Gervais)	Prichard		

Table 2: Mass production of *Neoseiulus longispinosus* on *Withania somnifera* infested with *Tetranychus macfarlanei*

Name of Plant	No. of prey mites released/ leaf	No. of predatory mites released	Mean no. of predatory mites harvested after 20 days of predator released
Withania somnifera	20	10	160
Withania somnifera	30	10	193

Table 3: Mass production of *Neoseiulus longispinosus* on *Withania somnifera* infested with *Tetranychus macfarlanei* at different ratios

Name of Plant	No. of prey mites : predatory mites	Mean no. of predatory mites harvested after 20 days
Withania somnifera	20: 3	192.53
Withania somnifera	30:5	273.16

Table 4: Evaluation of predatory mite,*Neoseiulus longispinosus* against *Tetranychus macfarlanei* in potted *Withania somnifera* plants covered with screen

Treatments	Number of mites/4cm^2 leaf area						Mean population increase on different treatments
	Mean initial population of predatory mite on different doses of prey	Increase of predator population on different days after release					
		01	04	08	12	16	
N. longispinosus @ 10 predators / potted plant	22.89	19.72	16.42	8.53	5.12	3.12	10.58
N. longispinosus @ 15 predators / potted plant	25.91	20.75	12.77	5.13	3.63	2.11	8.87
N. longispinosus @ 20 predators / potted plant	26.12	19.54	10.15	4.10	2.59	1.98	7.67
N. longispinosus @ 25 predators / potted plant	26.19	16.59	7.12	3.12	1.15	0.55	5.70
Control (No predatory mite)	22.57	27.32	31.54	34.21	21.50	18.01	26.51

Conclusion

A total of 36 species belonging to 15 genera and 7 families under 3 orders were observed during the present study (Table-1). A number workers have conducted surveys for exploring mites on medicinal plants and agri horticultural crops [1, 3-5, 7-15] at different locations of West Bengal but none of those surveyed as extensively as has been done now at the coastal areas of West Bengal. It was observed that, in case of mass multiplication at a release of 20 prey mites with 3 predators, the mean harvested predatory mites was 192.53 and the corresponding figure for 30 prey and 5 predator mites, the harvested predator was 273.16 (Table-3). The present study also shows that of 25 predator per plant *N. longispinosus* will be effective for control of *T. macfarlanei* on *Withania somnifera* (Table-4). From the above literature survey, it can be assumed that most of the workers have worked on the bio-control of one particular phytophagus mite *Tetranychus* urticae with different predatory mites like *Neoseiulus californicus*, *Neoseiulus californicus* and *Typhlodromus bagdasarjani* [22, 24-27]. Schausberger and Walzer, [23] observed *P. persimilis* and *N. californicus* could have complementary effects and a combination of the two predators could enhance long-term biological control of spider mites *Tetranychus cinnabarinus* Boisduval. Adar *et al.* [30] worked on the bio-control of *Polyphagotarsonemus latus with Euseius scutalis on* pepper in greenhouses conditions. Very little work is done on the bio-control of *Tetranychus macfarlanei* Baker & Pritchard which is also a major spider mite pest with wide host range with *Neoseiulus womersleyi* [28, 29]. But no information is available regarding the bio-control of *Tetranychus macfarlanei* with *Neoseiulus longispinosus* (Schicha).

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Conflict Of Interest

Authors declare that they have no conflict of interest.

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