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Diversity and host specialization of Tarsonemini mites (Acari, Tarsonemidae)—Investigations in the agroclimatic zones of West Bengal, Eastern India

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ABSTRACT. A vast number of tropical and subtropical mites belong to the family Tarsonemidae Canestrini & Fanzago, 1877, with the tribe Tarsoenmini under subfamily Tarsoneminae having the most diverse assemblage. In order to better understand the distribution, community structure, and host specificity of these mites, it is important to investigate the Tarsonemini mite fauna of India, particularly in the highly biodiverse state of West Bengal. A total of 1154 mite specimens were obtained from 69 distinct plant species belonging to 44 families and distributed over six agroclimatic zones in West Bengal. The mites were classified into 8 distinct genera and 38 morphospecies. We developed bipartite trophic networks for Tarsonemini mites for the first time to show how these different communities of these mites are associated to various host plant species in six different agroclimatic zones. Different network descriptors such as Connectance, *H2*, Niche Overlap and Robustness were calculated from the mite-plant networks of six agroclimatic zones. Northern Hill Zone had the highest diversity followed by New Alluvial and Teesta-Terai Zone whereas, Red Laterite Zone had the least diversity of mite species. More than 70% Tarsonemini mites were found as generalist plant inhabitants which is consistent with their epiphytotic microbivorous feeding strategy.

Key words: Bipartite network, biodiversity, community structure, conservation, distribution, ecosystem, mites

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INTRODUCTION

The state of West Bengal located in the eastern region of India constitutes about 2.7% of the total land area of the country and supports 12.27% of its biodiversity (Sanyal et al., 2012). The state's ecological diversity is reflected in the various ecosystem types that exist there, including the mountain ecosystem in the north, the forest ecosystem that covers the majority of the state, the freshwater ecosystem, the semi - arid ecosystem in the west, the mangrove ecosystem in the south, and the coastal marine ecosystem along the shoreline. This resulted into formation of six agroclimatic zones with well-defined boundaries viz. Northern Hill Zone, Teesta-terai Zone, Old Alluvial Zone, New Alluvial Zone, Red-laterite Zone, and Coastal-saline Zone (Basu, 2020). With a faunal record of around 10,013 species, West Bengal is one of the most biodiverse states in India (Anonymous, 2019). Prostigmatid mites make up just 0.03 percent of this fauna of which only three groups viz. Eriophoyidea, Tetranychidae, and Tenuipalpidae, have undergone decent taxonomic and ecological investigation, but only over the past two years, the study of Tarsonemidae has been intensified in India, notably in West Bengal (Gupta, 1985; Mondal et al., 2022; Mondal & Karmakar, 2022; Mondal, 2022).

The family Tarsonemidae Canestrini & Fanzago, 1877 consists of a group of tropical and subtropical mites comprising 47 genera, 8 tribes, and 3 subfamilies, with the tribe Tarsoenmini Canestrini & Fanzago, 1877 under subfamily Tarsoneminae having the most diverse assemblage with over 400 species from 18 genera (Lindquist, 1986; Kaliszewski, 1993; Lin & Zhang, 2002; Lofego & Feres, 2006; Lofego et al., 2015; Khaustov & Abramov, 2017; Lofego et al., 2019; Mondal & Karmakar, 2021a; Khaustov et al., 2022). Various genera of Tarsonemini mites, which live in a range of terrestrial, arboreal, subcortical, and nidicolous habitats contain mostly fungivorous, algivorous and rarely phytophagous and insect parasitic species (Lindquist, 1969; Walter & Proctor, 2013; Childers & Ueckermann, 2020). There are currently about 23 species of Tarsonemini mites known from India, with 15 of those species being found in West Bengal alone and covering multiple agroclimatic zones (Mondal & Karmakar, 2021a, 2021b, 2021c, 2021d; Mondal et al., 2021a, 2021b).This prompted us to investigate the diversity and community structure of these mites to comprehend the variation in their distribution and abundance with level of host plant specialization.

The purpose of this study was to assess the distribution of Tarsonemini mites in various agroclimatic zones of West Bengal and to reveal the hidden diversity of Tarsonemini mites in the tropical biomes of South Asia. The key claim being tested here is that undisturbed natural ecosystems in the state's northern regions support more diversity than anthropogenically disturbed habitats like farmland and nearby ecosystems in the central and southern parts of the state. Additionally, by constructing bipartite networks, we examined whether the Tarsonemini mite-plant interactions are more specialized, as predicted from the intimate evolutionary association between plants and their herbivores, or more generalized, as expected from these mites' propensity to feed on epiphytic microorganisms.

MATERIAL AND METHODS

Study area and mite collection. West Bengal (20°03'–27°12' North and 85°50'–89°52' East), a state in the Eastern India, is bordered on the north by Sikkim and Bhutan, on the east by Assam and Bangladesh, on the south by the Bay of Bengal and on the west by Orissa, Bihar, and Nepal. A total of 1154 specimens were collected from 40 locations distributed in the six agroclimatic zones of West Bengal surveyed during the present study. Figure 1 shows the sampling areas that were surveyed. At each location, rapid roving surveys were carried out on a variety of herbs, shrubs, creepers, trees, and allied weed species that were present in the same habitat during the period of October, 2019 to March, 2021.

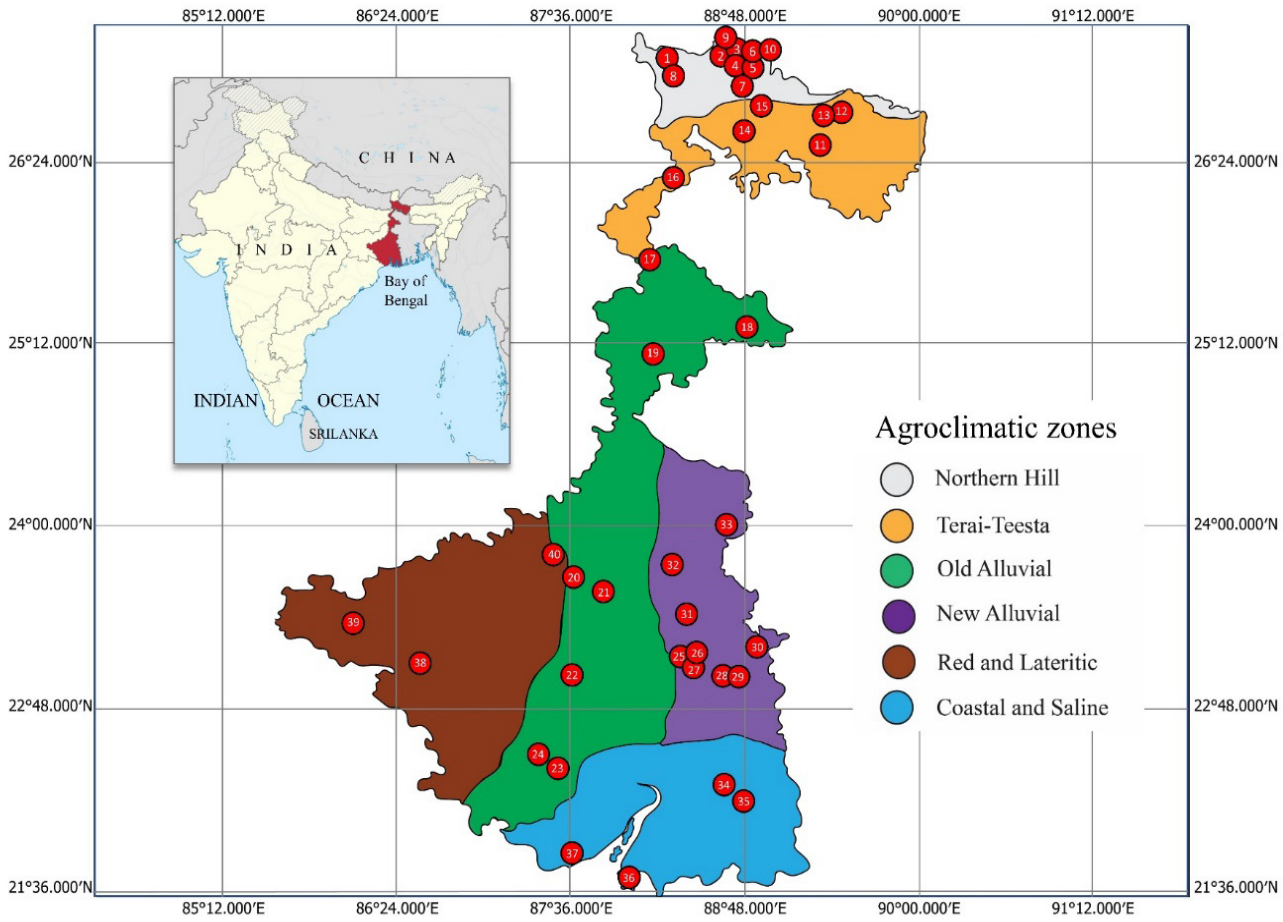

Figure 1. Map showing collection sites across different agroclimatic Zones of West Bengal, India.

In the Northen Hill Zone and Teesta-terai Zone, which includes the dense Himalayan and Dooars forests, a total of sixteen locations were surveyed. The mites were collected from seventeen sites from the Gangetic alluvial basins, with eight of those locations falling within the Old Alluvial Zone and nine within the New Alluvial Zone. Landscapes in alluvial basins are dominated by agricultural farmlands or patches of small open forests that frequently experience human intervention. Three of the sampling locations were in the semi-arid ecosystems of the Red-laterite zone, and four were in the mangrove ecosystem of the coastal-saline zone. A minimum distance of 10 km. was maintained as buffer between two adjacent sampling locations.

Leaf, and bark samples from each plant species were collected in a 12 × 16 inch zipper bag. A total of 91 samples were fetched from 69 different plant species distributed over the six zones of West Bengal. In laboratory, the mites were collected from the samples using a fine camel toothbrush (size 00), watched under a stereoscopic zoom microscope, and mounted in modified Berlese's medium (Amrine & Manson, 1996) for inspection. With the use of a phase and differential interference contrast microscope (Olympus® BX53), the mites were further examined for taxonomic identification. For recognized species, every specimen was categorized down to the species level, whereas unidentified species were divided into various morphospecies. All specimens are deposited in the Acarology Laboratory Museum, Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya (State Agricultural University) located at Mohanpur, state of West Bengal, India.

Shannon's diversity index. Shannon diversity (H) was calculated by the following equation (Shannon, 1948):

$$H = -\sum_{i=1}^{s} p_i \; ln \, p_i$$

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) and s is the number of species.

Bray-Curtis dissimilarity. The dissimilarity Bray-Curtis index (BC_{ij}) was calculated by the following equation (Bray & Curtis, 1957):

$$BC_{ij} = (1 - 2 \times C_{ij})/(S_i + S_j)$$

Where, C_{ij} refers to the sum of the lesser values for the species found in each site; Si refers to total no. of specimens collected at site i and S_j is the total no. of specimens collected at site j. The dissimilarity ranges from 0 to 1, with 0 representing perfect similarity and 1 indicating complete heterogeneity of species composition. A cluster analysis was carried out based on the dissimilarity to illustrate the divergences in the Tarsonemini species assemblage of six different agroclimatic zones. The dendrogram was constructed using package *Vegan* (Oksanen et al., 2017) in RStudio® (R Core Team, 2013).

Bipartite mite-plant networks. Ecological trophic networks were constructed using the 'bipartite' package in RStudio® to understand number and intensity of interaction between mites and their host plants (Dormann et al., 2009; Dormann, 2011). We used the topological descriptors Connectance, Niche overlap and Robustness to understand the variation of interactions among six different agroclimatic zones.

Connectance (C) is the proportion of observed interactions compared to the possible interactions in the network ranging of 0 (totally specialized) to 1 (totally connected or generalized). The mean similarity in the interaction patterns between species at the same trophic level was used to determine the niche overlap of the mite species. Values near 0 indicate that mites in the relevant network use less shared niches (host plants), whereas 1 indicates complete niche overlap. The descriptor robustness models the rate at which mite fauna would disappear when plant species go extinct, with values close to 0 suggesting an abrupt extinction of mite species and values close to 1 indicating a gradual rate of extinction (Dormann et al., 2009; Dunne et al. 2002; Blüthgen et al. 2006). Null models based on the "shuffle.web" algorithm were used to determine the significance of the observed values for each network descriptor. Furthermore, Paired Difference Index (*PDI*) was calculated for all the species occurring in West Bengal to understand their degree of specialization. *PDI* ranges between 0 (perfect generalist) and 1 (perfect specialist) (Dormann, 2011).

RESULTS

Distribution, abundance and diversity. A total of 38 species of Tarsonemini mites belonging to 8 different genera were collected from West Bengal. In the Northern Hill Zone (NHZ), 265 Specimens comprising of 25 species were collected on 21 species of plants which represents 23% of the total number of specimens collected from the entire state. *Metatarsonemus connexus* was the most dominant species followed by *Floridotarsonemus kukri*, respectively accounting for 13.58% and 11.69% of total population in this zone while *Tarsonemus* sp.5 was found rarest with only 1 specimen. On 12 types of plants from the Teesta-Terai Zone, a total of 154 specimens representing 16 species were collected (TTZ). This accounts for 14% of all specimens from West Bengal. *Metatarsonemus badurkani* was the most dominant species followed by *Tarsonemus* sp.7 representing 23.37% and 18.18% of entire population while *Fungitarsonemus* sp.1 was the least abundant species with only 2 specimens. On 20 species of plants from the New Alluvial Zone (NAZ), a total of 383 Tarsonemini mites belonging to 17 species were obtained which represents 33% of the total population from the state and is the highest among all the six zones. *Tarsonemus narkelae* was the most prevalent species followed by *Tarsonemus* sp.7 and *T. mondouriensis* representing 20.36%, 10.96%, 10.71% of total population, respectively and, *Floridotarsonemus* sp.1 exhibited poorest abundance with only 3 specimens in this zone. From the Old Alluvial Zone (OAZ), a total of 162 specimens, belonging to 13 species, were acquired from 13 different species of host plants taking the share of 13.5% of all specimens from West Bengal. *Tarsonemus* sp.7 was the most prevalent species followed by *T. narkelae* representing 21.60% and 14.8% of entire population, respectively while *Fungitarsonemus baganbilasae* was the rarest with only 1 specimen. The Red Laterite Zone (RLZ) had the fewest Tarsonemini mites among all of the six zones with just 61 specimens (5% of the total) belonging to 9 species on 9 different host plants. *Tarsonemus* sp.7 was the most dominant species representing 39.34% of total population while *Daidalotarsonemus* sp.2, *Tarsonemus* sp.1, *Fungitarsonemus baganbilasae* were the least abundant species, each with only 2 specimens. A total of 129 specimens comprising of 12 species were collected on 12 species of plants from the Coastal Saline Zone (CSZ). The zone represents 11.5% of total number of specimens collected from the entire state during the present study. *Tarsonemus narkelae* and *T. mondouriensis* were the most dominant species each representing 19.38% of total Tarsonemini population in this zone while *Metatarsonemus* sp.1 was the least abundant species with only 2 specimens. A heatmap indicating the abundance of different Tarsonemini species across six agroclimatic zones of West Bengal is presented in Table 1.

A comparative study of species diversity in six different agroclimatic zones of West Bengal (Fig. 2a) revealed highest Shannon index (*H*) in the Northern Hill Zone (2.80) followed by New Alluvial Zone (2.58) and Teesta Terai Zone (2.40). Old Alluvial Zone and Coastal Saline Zone both exhibited moderately high *H* values of almost 2.25. The Red Laterite Zone had the lowest *H* value (1.84).

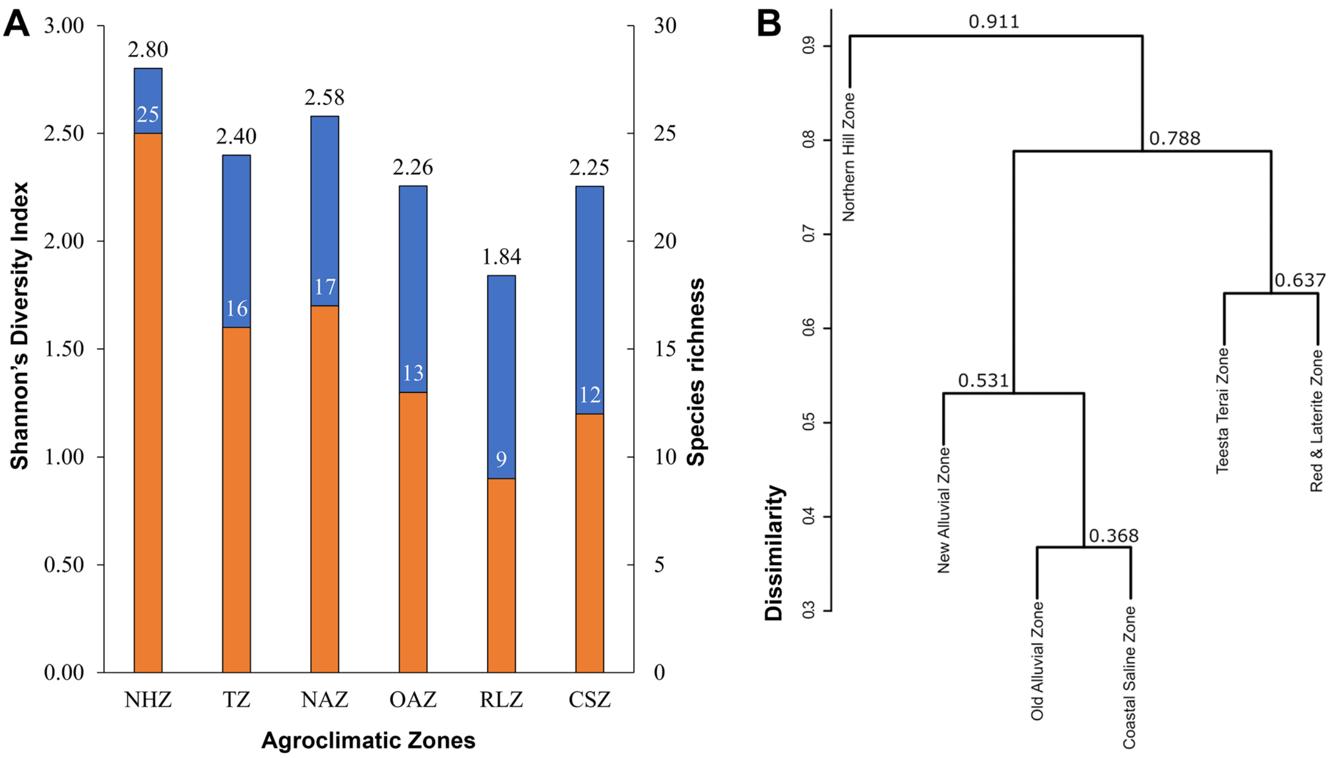

Figure 2. A. Species richness and Shannon's index of Tarsonemini mite diversity across six agroclimatic zones of West Bengal; **B.** Dendrogram of species assemblage in six different agroclimatic zones of West Bengal based on Bray-Curtis dissimilarity index.

Table 1. Abundance and distribution of Tarsonemini species in Six different agroclimatic Zones of West Bengal, India. (colour codes: green-absent; yellow to red-increase in abundance).

Morphospecies	NHZ	TTZ	NAZ	OAZ	RLZ	CSZ	Literature with descriptions
Bongotarsonemus bicornus	16	0	0	0	0	0	Mondal & Karmakar (2021a)
Bongotarsonemus unicornus	14	0	0	0	0	0	Mondal & Karmakar (2021a)
Ceratotarsonemus bengalicus	8	0	0	0	0	0	Kayal et al. (2022)
Daidalotarsonemus duolamella	20	0	0	0	0	0	Lin et al. (1998)
Daidalotarsonemus sp.1	0	5	0	0	0	0	-
Daidalotarsonemus sp.2	0	9	12	0	2	5	-
Daidalotarsonemus sp.3	8	0	0	0	0	0	-
Daidalotarsonemus sp.4	6	0	0	0	0	0	-
Daidalotarsonemus tambulae	0	0	19	2	0	5	Mondal & Karmakar (2022)
Floridotarsonemus kathali	0	20	20	0	0	0	Mondal & Karmakar (2021b)
Floridotarsonemus kukri	31	8	0	5	0	0	Mondal & Karmakar (2021b)
Floridotarsonemus sp.1	5	6	3	0	0	0	-
Floridotarsonemus sp.2	4	6	0	0	0	0	-
Fungitarsonemus baganbilase	4	0	20	1	2	8	Mondal & Karmakar (2021c)
Fungitarsonemus icchepaharicus	8	4	0	0	0	0	Mondal & Karmakar (2021c)
Fungitarsonemus rishyapensis	13	0	0	0	0	0	Mondal & Karmakar (2021c)
Fungitarsonemus sp.1	3	2	11	10	3	0	-
Fungitarsonemus sp.2	5	0	0	0	0	0	-
Fungitarsonemus sp.3	0	0	0	0	0	7	-
Metatarsonemus badurkani	10	36	14	23	8	14	Mondal & Karmakar (2021d)
Metatarsonemus connexus	36	3	0	0	0	0	Mondal et al. (2021a)
Metatarsonemus diplojuga	9	9	0	0	0	0	Mondal et al. (2021a)
Metatarsonemus infundibulum	12	0	0	0	0	0	Mondal et al. (2021a)
Metatarsonemus sirishi	0	0	33	0	0	0	Mondal & Karmakar (2021d)
Metatarsonemus sp.1	3	6	0	6	0	2	-
Metatarsonemus sp.2	8	0	14	0	0	0	-
Tarsonemus sp.7	0	28	42	35	24	4	-
Tarsonemus mondouriensis	0	0	41	21	0	25	Mondal et al. (2021b)
Tarsonemus sp.1	0	0	19	8	2	6	-
Tarsonemus sp.2	0	6	11	6	0	0	-
Tarsonemus sp.3	0	0	4	0	0	0	-
Tarsonemus sp.4	19	0	0	0	8	0	-
Tarsonemus sp.5	1	0	0	0	0	0	-
Tarsonemus sp.6	0	0	0	0	6	0	-
Tarsonemus narkelae	3	3	78	24	0	25	Mondal & Karmakar (2021d)
Xenotarsonemus krishnai	14	0	0	0	0	0	Mondal et al. (2022)
Xenotarsonemus sp.1	0	3	25	15	6	12	-
Xenotarsonemus sp.2	5	0	17	6	0	16	-

The Northern Hill Zone had the highest number of species (25) and 87 percent species evenness, which led to a higher Shannon index (*H*) for this area. Teesta Terai Zone's species evenness (87%) was comparable to Northern Hill Zone's, but its lower species richness (16) led to a lower *H* index (2.40). When compared to the Teesta Terai Zone (16), the New Alluvial Zone (17) had somewhat higher species richness and also higher species evenness (91 percent), which led to a comparatively higher *H* index (2.58). Because of their nearly same species evenness and equivalent species richness, the Old Alluvial Zone and the Coastal Saline Zone produced similar Shannon indices. The Red Laterite Zone (RLZ) had the lowest *H* index because of the least species richness compared to other five zones. A dendrogram representing similarity of Tarsonemini species assemblage in six different agroclimatic zones of West Bengal was constructed based on Bray-Curtis dissimilarity index (Fig. 2b). Northern Hill Zone was completely different from other five agroclimatic zones with 91.1% dissimilarity in species assemblage. The Teesta-Terai Zone and Red Laterite Zone together formed a cluster with 78.8% dissimilarity from another cluster constituting two Alluvial Zones and Coastal Saline Zone. The Teesta Terai Zone differed from Red Laterite Zone by 63.7% dissimilarity in species assemblage. New Alluvial Zone differed from OAZ & CSZ by 53.1% dissimilarity while the latter two differed by only 36.8% dissimilarity in species assemblage.

Ecological networks

Plant-mite network in NHZ. The network was comprised of 46 interactions (Fig. 3a). 10 out of 25 species were found host specific viz. *Bongotarsonemus bicornus* on *Arthromeris wallichiana* (Spreng.); *B. unicornus* on *Prunus avium* L.; *Ceratotarsonemus bengalicus* on *Citrus reticulata Blanco; Floridotarsonemus* sp.2 on *Rhododendron indicum* L.; *Fungitarsonemus baganbilasae* on *Bougainvillea* sp.; *F. icchepaharicus* on *C. reticulata; Fungitarsonemus* sp.1 *on Michelia dolstopa* Buck.; *Metatarsonemus* sp.1 on *Camellia sinensis* L.; *Tarsonemus narkelae* on *Mangifera indica* L. and *Tarsonemus* sp.5 on *A. walllichiana.* Mites having highest interaction were *Floridotarsonemus kukri* and *Metatarsonemus badurkani* each with 4 host plants followed by *Daidalotarsonemus* sp.3 and *Metatarsonemus connexus* each with 3 host plants. Plants sheltering highest mite species were *R. indicum* with 6 mite species followed by *C. reticulata* with 5 mite species inhabiting different plant parts. The connectance ($C = 0.089$) was recorded as the lowest among the six agroclimatic zones. It did not differ from null model value ($Null\ C = 0.089 \pm 0.001$, $p < 0.001$). The observed niche overlap for mite species ($N = 0.062$) was the lowest among six zones and was higher than the null model value ($Null\ N = 0.053 \pm 0.007$, $p = 0.238$). Observed robustness was the lowest ($R = 0.651$) but was higher than the null model value ($Null\ R = 0.648 \pm 0.011$, $p = 0.302$).

Plant-mite network in Teesta Terai Zone. The network was comprised of 42 interactions (Fig. 3b). Five species viz. *Fungitarsonemus icchepaharicus*, *Fungitarsonemus* sp.1, *Metatarsonemus connexus*, and *Tarsonemus narkelae* were found host specific on *Ixora coccinea*, *Piper nigrum*, *Calotropis gigantia* and *Streblus aspur*, respectively. Mites having highest interaction were *Metatarsonemus badurkani* with 6 host plants followed by *Floridotarsonemus* sp.1 and *Tarsonemus* sp.2 each with 4 host plants. Plants sheltering highest mite species were *Zizyphus* sp. with 5 mite species followed by *Camellina sinensis* (L.), *Citrus* sp., *Neolamarckia cadamba* (Roxb.), *Streblus asper* Lour. and *Syzygium jambos* L. and each with 4 Tarsonemini species inhabiting different plant parts. The observed connectance ($C = 0.219$) was recorded as the second highest among the six agroclimatic zones. It did not differ from null model value ($Null\ C = 0.218 \pm 0.001$, $p < 0.001$). The observed niche overlap for mite species ($N = 0.141$) was the second highest among all zones, but did not differ from the null model value ($Null\ N = 0.139 \pm 0.002$, $p = 0.379$). Observed robustness ($R = 0.784$) also did not deviate from the null model value ($Null\ R = 0.779 \pm 0.012$, $p = 0.426$) and was highest among all six zones.

Plant-mite network in New Alluvial Zone. The plant-mite network comprised of 52 interactions (Fig. 4a). Only *Tarsonemus* sp.3 and *T. mondouriensis* were found host specific on *Albizia lebbeck* (L.) and *Oryza sativa* L., respectively. Mites having highest interaction were *Tarsonemus* sp.1 with 7 host plants followed by *T. narkelae* and *Xenotarsonemus* sp.1 with 6 and 5 host plants, respectively.

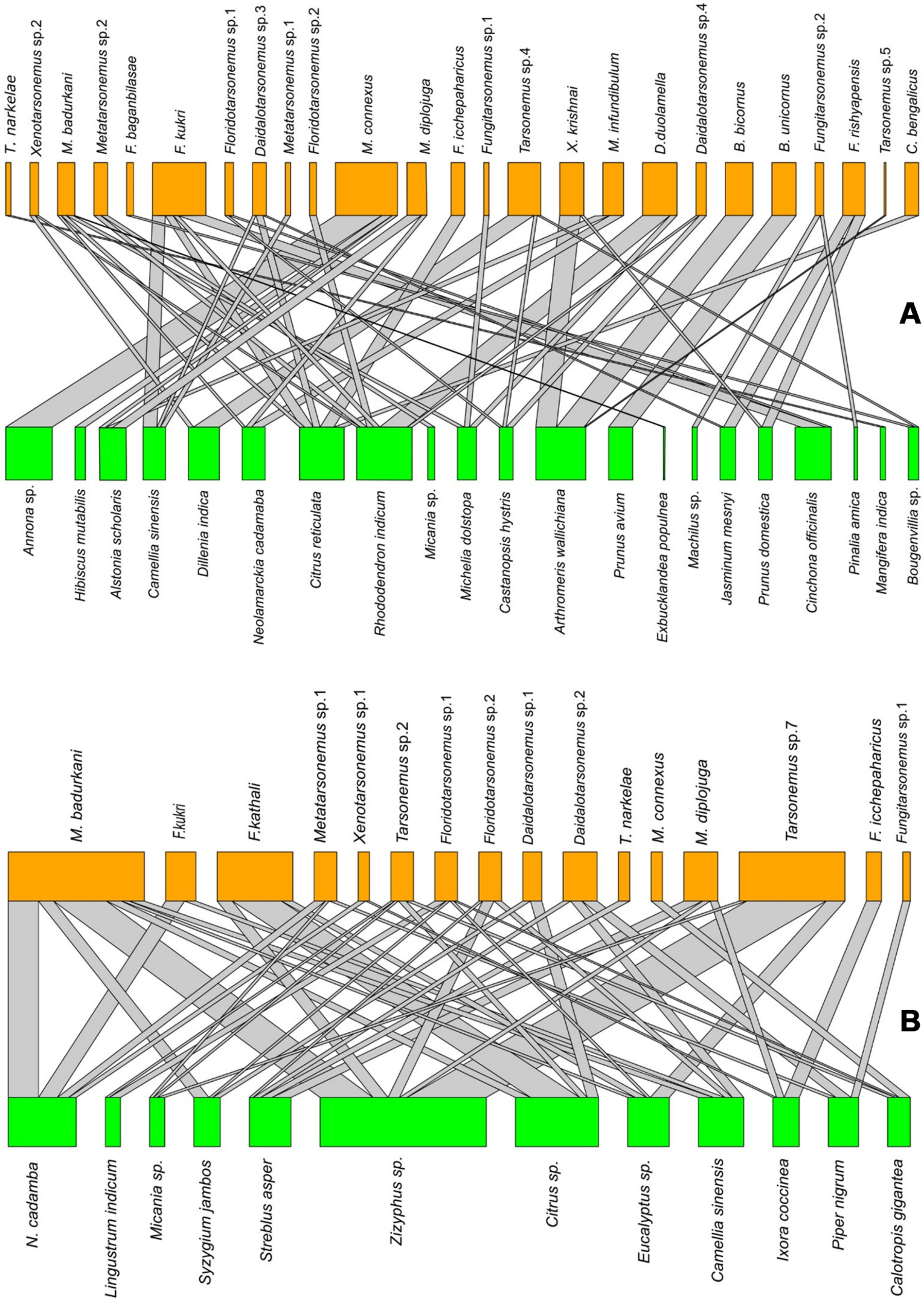

Figure 3. Bipartite mite-plant network in **A.** Northern Hill Zone; **B.** Teesta Terai Zone of West Bengal.

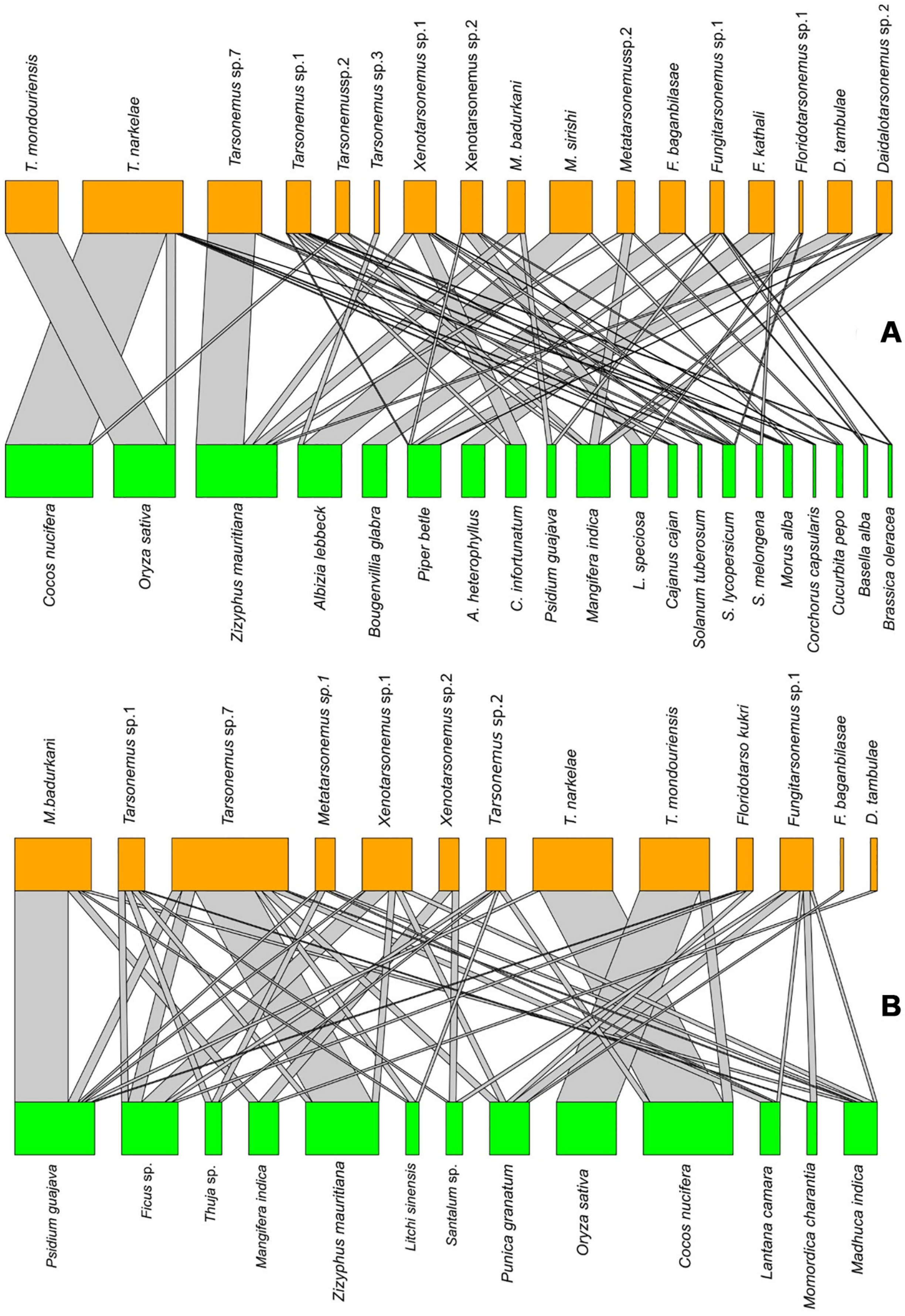

Figure 4. Bipartite mite-plant network in **A.** New Alluvial Zone; **B.** Old Alluvial Zone of West Bengal.

Plants sheltering highest mite species were *Mangifera indica* L., *Piper betle* L., *Solanum lycopersicum* L., *Zizyphus mauritiana* Lam., each with 5 Tarsonemini mite species inhabiting different plant parts. The observed connectance was fairly good (*C* = 0.15) and second lowest among the six agroclimatic zones. It did not differ from null model value (*Null C* = 0.15 ± 0.001, $p < 0.001$). The observed niche overlap for mite species (*N = 0.086*) was second lowest among all zones, and was significantly lower than null model value (*Null N* = 0.099 ± 0.004, *p* = 0.1). Robustness observed was relatively high (*R* = 0.70) which was also greater than the null model value (*Null R* = 0.68 ± 0.01, *p* = 0.737). It was third highest among all six zones.

Plant-mite network in Old Alluvial Zone. The plant-mite network comprised of 45 interactions (Fig. 4b). Only *Fungitarsonemus baganbilasae* and *Daidalotarsonemus tambulae* were found host specific on *Punica granatum* L. and *Mangifera indica* L., respectively. However, their low number of abundance (1-2 individuals) might be anecdotal evidence of plant-mite interaction. Mites having highest interaction were *Tarsonemus* sp.7 with 7 host plants followed by *Fungitarsonemus* sp.1, *Tarsonemus* sp.1 and *Xenotarsonemus* sp.1 each with 5 host plants. Plants sheltering highest mite species were *Psidum guajava* L. with 6 mite species followed by *Ficus* sp., *Madhuca indica* Macbr., *Punica granatum* L. each with 5 Tarsonemini mite species inhabiting different plant parts. The observed connectance (*C* = 0.266) was the highest among the six agroclimatic zones. It did not differ from null model value (*Null C* = 0.266 ± 0.001, $p < 0.001$). The observed niche overlap for mite species (*N* = 0.156) was highest among all zones, and did not differ from the null model value (*Null N* = 0.143 ± 0.012, *p* = 0.1). Robustness observed was relatively high (*R* = 0.778) but lower than the null model value (*Null R* = 0.776 ± 0.012, *p* = 0.638). It was second highest among all six zones.

Plant-mite network in Red Laterite Zone. The plant-mite network was comprised of 16 interactions (Fig. 5a). *Daidalotarsonemus* sp.2, *Fungitarsonemus baganbilasae Tarsonemus* sp.1 and *Tarsonemus* sp.6 were found host specific on *Butea monosperma* (Lam.), *Eucalyptus* sp. *Schleichera oleosa* (Lour.) and *Shorea robusta* Roth., respectively. *Fungitarsonemus* sp.1 and *Metatarsonemus badurkani* were found to inhabit only *Alstonia scholaris*. The mite having highest interaction was *Tarsonemus* sp.7 with 6 host plants. Plant sheltering highest mite species was *Butea monosperma* (Lam.) with 4 mite species inhabiting different plant parts. The observed connectance (*C* = 0.198) was recorded as the third highest among the six agroclimatic zones. It did not differ from null model value (*Null C* = 0.197 ± 0.001, $p < 0.001$). The observed niche overlap for mite species (*N* = 0.124) did not differ from the null model value (*Null N* = 0.110 ± 0.025, *p* = 0.117). Observed robustness (*R* = 0.628) also did not deviate from null model value (*Null R* = 0.625 ± 0.012, *p* = 0.739) and was lowest among all six zones.

Plant-mite network in Coastal Saline Zone. The plant-mite network was comprised of 24 interactions (Fig. 5b). Only *Metatarsonemus* sp.1 and *Tarsonemus* sp.7 were found host specific on *Shorea robusta* Roth and *Commelina benghalensis* L., respectively. Mites having highest interaction were *T. mondouriensis*, *T. narkelae* and *Xenotarsonemus* sp.1 each with 3 host plants. Plants sheltering highest mite species were *Shorea robusta* with 5 mite species followed by *Psidium guajava* L. with 3 mite species inhabiting different plant parts. The observed connectance (*C* = 0.174) was recorded as the second lowest among the six agroclimatic zones. It did not differ from null model value (*Null C* = 0.173 ± 0.001, $p < 0.001$). The observed niche overlap for mite species was relatively low (*N* = 0.115) and did not differ from the null model value (*Null N* = 0.102 ± 0.018, *p* = 0.485). It indicates relatively lower use of common niches (host plant species) by different mite species involved in this network. Observed robustness was moderate (*R = 0.659*) and did not deviate from the null model value (*Null R* = 0.647 ± 0.012, *p* = 0.302). A comparison between the network descriptors of six agroclimatic zones is presented in Figure 6. Only 6 of the 38 species were found as perfect specialists (*PDI* = 1) interacting with single plant species, accounting for only 15.78 percent of the total Tarsonemini mite diversity in West Bengal (Fig. 7). In the Northen Hill Zone, *Bongotarsonemus bicornus*, *B. unicornus*, *Ceratotarsonemus bengalicus* and *Tarsonemus* sp.5 specialized on *Arthromeris wallichiana*, *Prunus avium*, *Citrus reticulata* and *A. wallichiana*, respectively, and *Tarsonemus* sp.5 on *Shorea robusta* in the Red Laterite Zone.

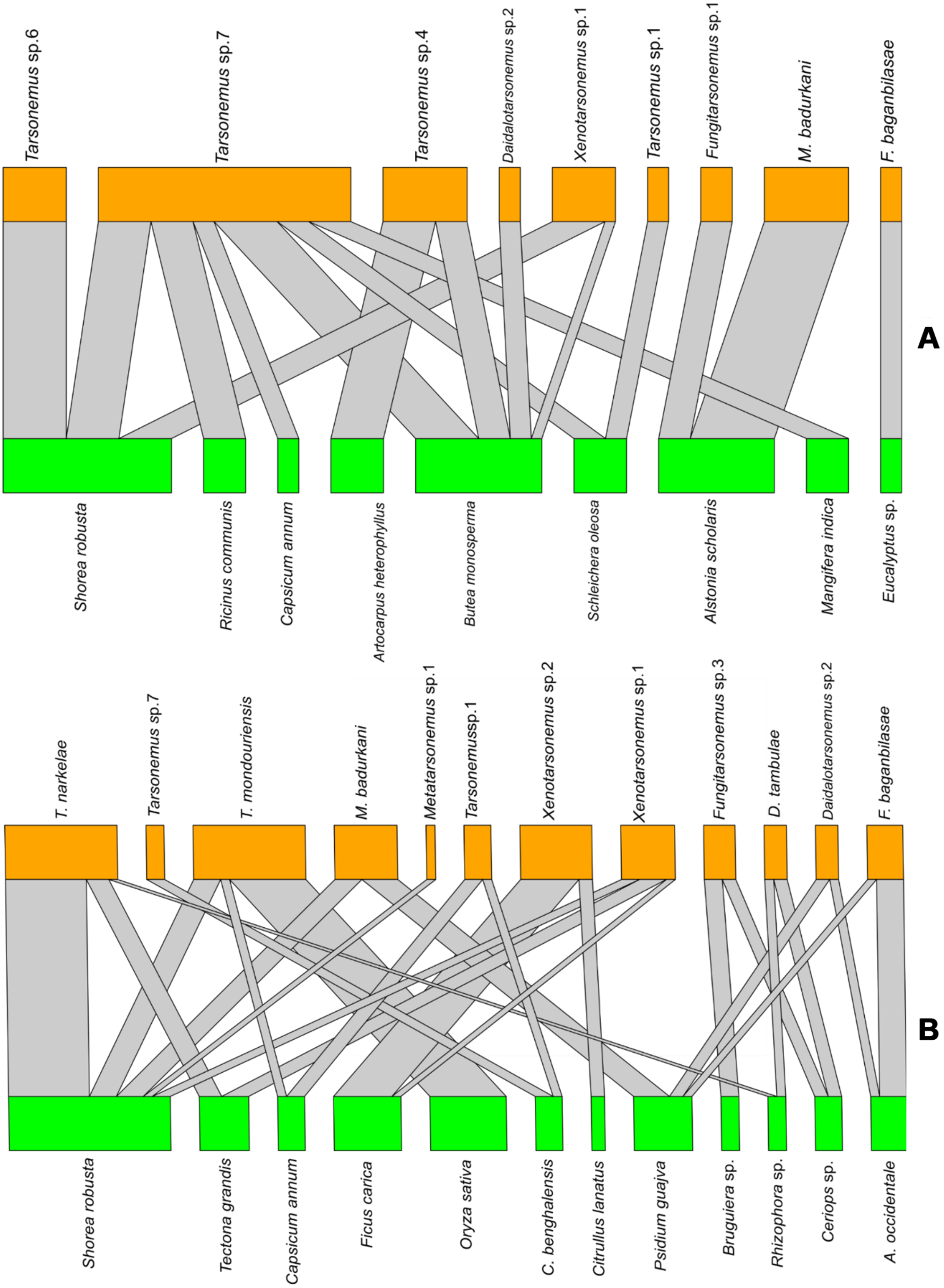

Figure 5. Bipartite mite-plant network in **A.** Red Laterite Zone; **B.** Coastal Saline Zone of West Bengal.

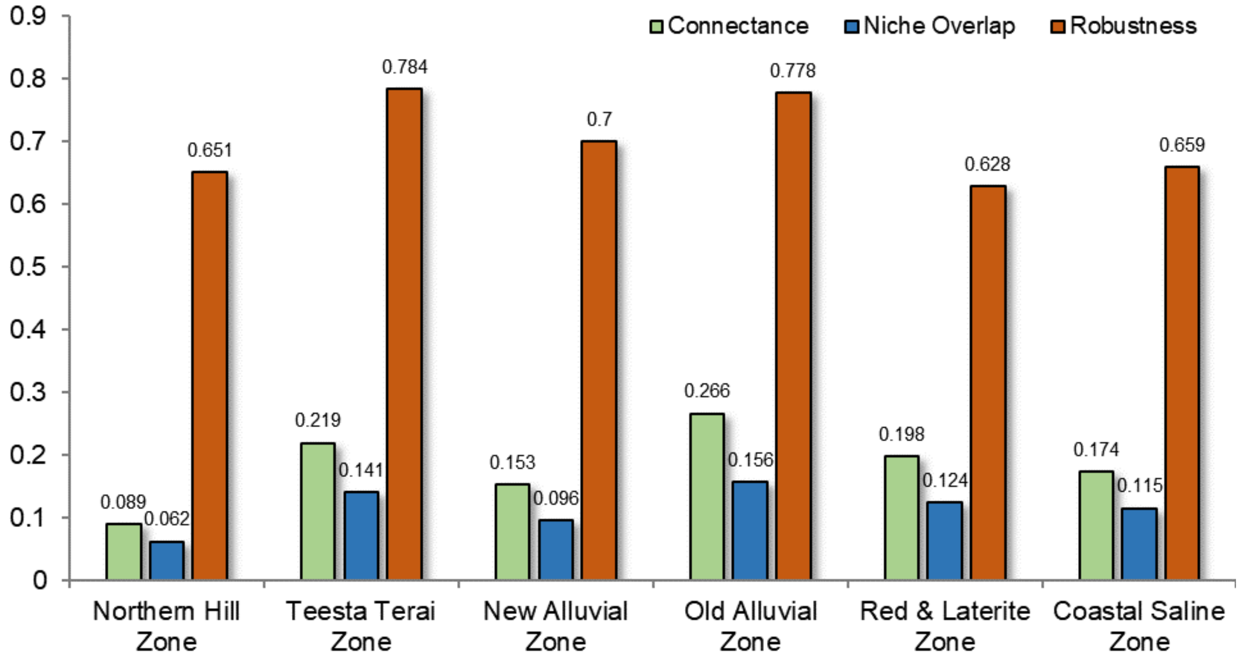

Figure 6. Zonewise comparison of network indices viz. Connectance, Niche Overlap and Robustness (Value with asterisk above it denotes significantly higher than expected by chance).

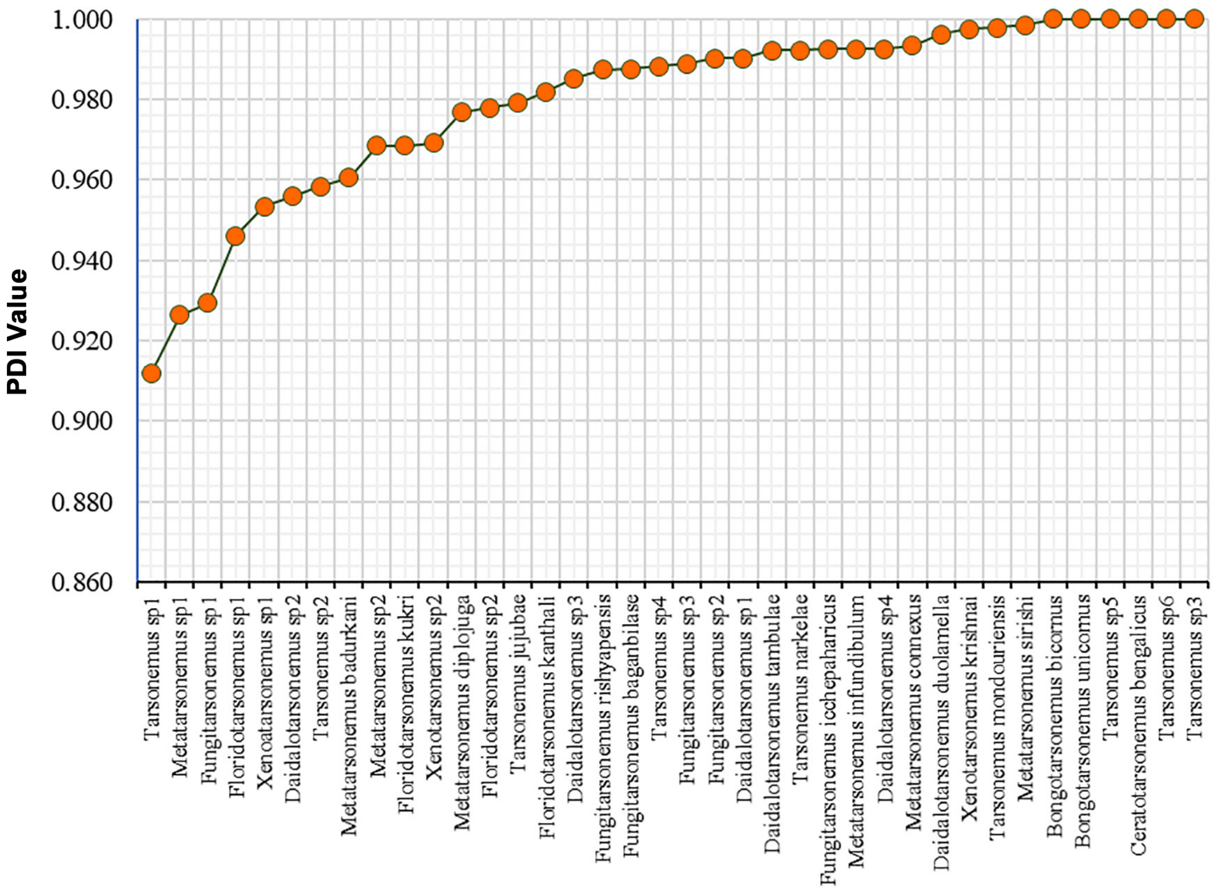

Figure 7. Paired Difference Index (*PDI*) score of 38 Tarsonemini mite species collected from six agroclimatic zones of West Bengal (Species are arranged in increasing order (specialization) from left to right.

DISCUSSION

Overall, the Tarsonemini mite species assemblage in Eastern India differs significantly from the species assemblage of New World and European species. This, however, may be further substantiated through recurrent surveys that span a larger geographic area and additional states in Eastern India. Located in the Central Himalayan biotic province, West Bengal's Northern Hill Zone is home to a diverse range of mite species, including Tarsonemidae (Mondal & Karmakar, 2021a). It is further supported by the findings of the current investigation. The undisturbed ecosystems of dense forests are a blessing for several species, protecting them from chemical contamination and the habitat fragmentation that is typical of anthropogenic habitats and agricultural ecosystems in the southern parts of West Bengal. The highest number (10) of endemic species was recorded in Northern Hill Zone viz. *Bongotarsonemus bicornus*, *Bongotarsonemus unicornus*, *Daidalotarsonemus* sp.3, *Daidalotarsonemus* sp.4, *Fungitarsonemus* sp.2, *F. icchepaharicus*, *F. rishyapensis*, *Metatarsonemus infundibulum*, *Tarsonemus* sp.4 and *Xenotarsonemus krishnai*. Arable agricultural fields are highly disturbed, chemically polluted ecosystems made up of erratic, short-lived habitats that are unsuited for the majority of species, which has resulted in a continuous reduction in biodiversity (Altieri, 1999; Feledyn-Szewczyk et al., 2016).

The new Alluvial Zone had the second-highest Shannon-index after the Northern Hill Zone, which appears to defy the general trend of decreasing biodiversity in farmlands. This agroecological region is characterised by intensive cultivation of agricultural and horticultural crops. Although there were significantly fewer species in the NAZ, they were more evenly distributed, which may be the result of local adaptation of these species to agricultural landscapes. However, during the current investigation, the impact of forest patches around agroecosystems that can function as a species reservoir was not considered. The New Alluvial Zone also contained 3 endemic species viz. *Metatarsonemus* sp.2, *M. sirishi* and *Tarsonemus* sp.3. Contrarily, the Teesta Terai Zone at the foot of the Himalayas is primarily made up of moist deciduous forests that support a good diversity of Tarsonemini mites, although it was less prolific than the New Alluvial Zone due to lower equitability of species abundance. However, fewer sampling locations in TTZ, may possibly be a factor in this case. Only two species were found endemic in Teesta Terai Zone viz. *Daidalotarsonemus* sp.1 and *F. icchepaharicus*. Despite having contrasting agroclimatic characteristics, diversity between the Old Alluvial Zone and the Coastal Saline Zone was very similar. Extreme heat and aridity in the red laterite zone contributed to the low floral richness that resulted in the lowest Tarsonemini mite diversity. The Coastal Saline Zone and Red Laterite Zone each contained a single endemic species viz. *Fungitarsonemus* sp.3 and *Tarsonemus* sp.6, respectively. It shows both coastal and arid ecosystems are not so favourable for sustaining Tarsonemini mite species. *Metatarsonemus badurkani* was the only species found abundant in all the six agroclimatic zones. The second most common species covering at least 5 agroclimatic zones were *Fungitarsonemus* sp.1, *F. baganbilasae*, *Xenotarsonemus* sp.1, *Tarsonemus narkelae* and *T.* sp.7.

The connectance observed in the present study (C = 0.089–0.266 *or* 8.9–26.6%) is very high compared to other plant-phytophagous networks which may have been caused by a lack of host specificity in Tarsonemini mites (de Araújo et al., 2015; de Araújo & Daud, 2018; de Araujo & Kollar, 2019; de Araujo & Maia, 2021; de Araujo & Oliveira, 2021). The observed connectance of all six mite-plant networks was identical to what may have happened by chance. However slightly lower connectance in Northern Hill Zone reflects higher degree of host specificity in this region compared to other zones where connectance was recorded more than 10%. Based on the niche overlap, more use of common plants by each mite species was recorded the highest in Old Alluvial Zone followed by Teesta Terai Zone, Red Laterite Zone, Coastal Saline Zone, New Alluvial Zone and Northern hill zone. Higher niche overlap entails more widespread resource utilization which leads to more generalized interactions between mite and plant species. The assemblage of mite species was most robust to extinction of plant species in Teesta Terai Zone followed by Old Alluvial Zone, New Alluvial Zone, Coastal Saline Zone, Northern Hill Zone and Red Laterite zone. In order of decreasing robustness, it is projected that the extinction of plant species will also lead to the extinction of the mite species in the corresponding zones. The lack of true host plant specificity by Tarsonemini mites, as found in the case of true phytophagous mites, may have contributed to the observed indices not being statistically robust in most zones. This was further supported by the PDI scores of all the mite species collected during the present study. Mites with PDI score of 1 cannot be confirmed as phytophagous as no direct feeding on plant parts were observed. The fact that only six mite species, distributed over three genera, were discovered inhabiting a single host plant may be coincidental or merely the result of their specialised feeding on epiphytotic microorganisms which were grown over those particular plant species. It is quite significant to notice that the Tarsonemini mites were primarily discovered in unhealthy, damp plant tissues or phylloplanes that were covered in epiphytotic fungus, lichen, and other microorganisms during the investigation. Although these mites appear to be generalists when plants are considered as the host, they may have a preference for epiphytotic microorganisms or plant feeding tissue.Mondal & Karmakar found *Bongotarsonemus* feeding within the dried sporangia of a fern *Arthromeris wallichiana*. Few species were frequently observed in close proximity to leaf galls (Mondal & Karmakar, 2021a; Mondal et al., 2021a). Interesting theories also exist regarding their consumption of galled plant tissue or arthropods that produce gall (Lindquist, 1986; Kuhn, 1883).

It was claimed that some *Daidalotarsonemus* species have been seen consuming erenial tissue inside of eriophoyid galls (Beer, 1963). While several dead psyllid specimens along with *Metatarsonemus connexus* were found inside the psyllid galls on Annona leaves by Mondal et al. (2021a), it was unclear whether the mites were feeding on plant or insect tissue. On the other hand, the dispersal in certain species (genera?) is quite unusual. *Daidalotarsonemus* and *Excelsotarsonemus* species can traverse the wind and land on plants with shorter canopies that are not necessarily their host plants which is accomplished by using their broad, flattened feather-like setae (Ochoa & Oconnor, 1998; Sousa et al., 2018). A number of Tarsonemini mites that are phoretic on insects transmit plant pathogenic fungi from diseased to healthy plants and congregate on the diseased part in such a way that they appear as direct pest of the plant although they feed on diseased tissue or pathogen spores (Moser et al., 2010; Hofstetter & Moser, 2014). Present findings show that Tarsonemini mites are not intimately associated with any plant species. Instead, their preference for eating epiphytic fungus, algae, lichens and propensity to conceal themselves in microniches on phylloplane and fissures of bark result in a larger distribution on distantly related plant species.

AUTHOR'S CONTRIBUTION

The authors confirm their contribution in the paper as follows: Conceptualization, P.M. and K.K.; methodology, P.M.; software, P.M.; validation, P.M.; formal analysis, P.M. and M.G.; investigation, P.M., M.G., D.C.; resources, P.M., M.G., K.K. and S.K.G.; data curation, P.M.; writing original draft preparation, P.M; writing—review and editing, M.G., K.K. and D.C.; visualization, P.M.; supervision, K.K.; project administration, P.M. & K.K.; All authors have read and agreed to the published version of the manuscript.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this paper.

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REFERENCES

Altieri, M.A. (1999) The ecological role of biodiversity in agroecosystems. *Agriculture, Ecosystems and Environment*, 74 (1–3), 19–31. https://doi.org/10.1016/S0167-8809(99)00028-6

Amrine Jr, J.W. & Manson, D.C.M. (1996) Preparation, mounting and descriptive study of eriophyoid mites. In: Lindquist, E.E., Sabelis, M.W. & Bruin. J. (eds) *Eriophyoid Mites – Their Biology, Natural Enemies and Control*. *World Crop Pests*, Vol. 6. Elsevier Science Publishers, Amsterdam, pp. 383–396

Anonymous (2019) *Government of West Bengal, Directorate of Forest, Wildlife Wing*. Online Available at URL: http://www.westbengalforest.gov.in/wildlife.php [Accessed at 16 May 2022]

Basu, J.P. (2020) *Climate Change Vulnerability and Communities in Agro-climatic Regions of West Bengal, India: Theory and Practice*. Springer Nature. 189 p. https://doi.org/10.1007/978-3-030-50468-7

Beer, R.E. (1963) Social parasitism in the Tarsonemidae, with description of a new species of tarsonemid mite involved. *Annals of the Entomological Society of America*, 56 (2), 153–160. https://doi.org/10.1093/aesa/56.2.153

Blüthgen, N., Menzel, F. & Blüthgen, N. (2006) Measuring specialization in species interaction networks. *BMC Ecology*, 6 (1), 9. https://doi.org/10.1186/1472-6785-6-9

Bray, J.R. & Curtis, J.T. (1957) An ordination of the upland forest communities of southern Wisconsin. *Ecological Monographs*, 27 (4), 326–349. https://doi.org/10.2307/1942268

Childers, C.C. & Ueckermann, E.A. (2020) The Tetranychoidea, Tarsonemidae and Tydeoidea mite complex on Florida citrus between 1954 and 2014: pests or beneficials? *Systematic and Applied Acarology*, 25 (7), 1257–1278. https://doi.org/10.11158/saa.25.7.8

de Araujo, W. S. & Daud, R.D. (2018) Investigating effects of hostplant diversity on Brazilian mite richness in natural ecosystems. *Systematic and Applied Acarology*, 23 (8), 1598–1613. https://doi.org/10.11158/saa.23.8.10

de Araújo, W.S. & Maia, V.C. (2021) Topological structure of a tritrophic network composed of host plants, gall- inducing insects and parasitoids in a resting area in Brazil. *Entomological Science*, 24 (2), 201–216. https://doi.org/10.1111/ens.12468

de Araújo, W.S. & Oliveira, J.B.B.S. (2021) Plant–herbivore assemblages composed of endophagous and exophagous insects have different patterns of diversity and specialization in Brazilian savannas. *Biotropica*, 53 (4), 1013–1020. https://doi.org/10.1111/btp.12963

de Araújo, W.S., Vieira, M.C., Lewinsohn, T.M. & Almeida-Neto, M. (2015) Contrasting effects of land use intensity and exotic host plants on the specialization of interactions in plant–herbivore networks. *PLOS ONE*, 10 (1), e0115606. https://doi.org/10.1371/journal.pone.0115606

de Araújo, W.S. & Kollár, J. (2019) First characterization of a highly specialized ecological network composed by gall inducing mites and their host plants. *International Journal of Acarology*, 45 (4), 223–226. https://doi.org/10.1080/01647954.2019.1591505

Dormann, C.F. (2011) How to be a specialist? Quantifying specialisation in pollination networks. *Network Biology*, 1 (1), 1–20.

Dormann, C.F., Fründ, J., Blüthgen, N. & Gruber, B. (2009) Indices, graphs and null models: Analyzing bipartite ecological networks. *Open Ecology Journal*, 2 (1), 7–24. http://doi.org/10.2174/1874213000902010007

Dunne, J.A., Williams, R.J. & Martinez, N.D. (2002) Food-web structure and network theory: The role of connectance and size. *Proceedings of the National Academy of Sciences of the United States of America*, 99 (20), 12917–12922. https://doi.org/10.1073/pnas.192407699

Feledyn-Szewczyk, B., Kuś, J., Stalenga, J., Berbeć, A.K. & Radzikowski, P. (2016) The Role of Biological Diversity in Agroecosystems and Organic farming. In: Konvalina, P. (ed.) *Organic Farming-A Promising Way of Food Production*. IntechOpen, pp. 1–27. https://doi.org/10.5772/61353

Gupta, S.K. (1985) *Plant Mites of India*. Zoological Survey of India, Calcutta. 520 p.

Hofstetter, R.W. & Moser, J.C. (2014) The role of mites in insect-fungus associations. *Annual Review of Entomology*, 59, 537–557. https://doi.org/10.1146/annurev-ento-011613-162039

Kaliszewski, M. (1993) Key to palearctic of the genus *Tarsonemus* [Acari, Tarsonemidae]. *Seria Zoologiczna*, 14, 204.

Kayal, S., Mondal, P., Karmakar, K. (2022) The first record of Ceratotarsonemus (Acari: Tarsonemidae) from the Oriental region with description of a new species from West Bengal, India. *Zootaxa*, 5182 (3), 238–246. https://doi.org/10.11646/zootaxa.5182.3.2

Khaustov, A.A. & Abramov, V.V. (2017) A new genus and species of Tarsonemidae (Acari: Heterostigmata) associated with *Aradus betulae* (Heteroptera: Aradidae) from European Russia. *Acarologia*, 57 (4), 1079–1087. https://doi.org/10.24349/acarologia/20174220

Khaustov, A. A., Fjellberg, A., & Lindquist, E. E. (2022). A new genus and species of Pseudotarsonemoidini (Acari: Heterostigmata: Tarsonemidae) associated with xylophagous gall midges in Norway. *Systematic and Applied Acarology*, 27 (6), 1020–1034. https://doi.org/10.11158/saa.27.6.4

Kuhn, J. (1883) Eine neue Milbengalle auf dem Straussgrase. *Botanisches Centralblatt*, 13, 212.

Lin, J., & Zhang, Z.Q. (2002) *Tarsonemidae of the World (Acari: Prostigmata): Key to Genera, Geographical Distribution, Systematic Catalogue and Annotated Bibliography*, Systematic and Applied Acarology Society, London. 440 p.

Lin, J., Chen, Q. & Zhang, Z.Q. (1998) Three new species of *Daidalotarsonemus* from Fujian, China (Acari: Tarsonemidae*). Systematic and Applied Acarology*, 3, 137–143. https://doi.org/10.11158/saa.3.1.22

Lindquist, E.E. (1969) Review of Holarctic tarsonemid mites (Acarina: Prostigmata) parasitizing eggs of ipine bark beetles. *Memoirs of the Entomological Society of Canada*, 101 (S60), 5–111. https://doi.org/10.4039/entm10160fv

Lindquist, E.E. (1986) The world genera of Tarsonemidae (Acari:Heterostigmata): A morphological, phylogenetic, and systematic revision, with a reclassification of family-group taxa in the Heterostigmata. *Memoirs of the Entomological Society of Canada*, 118 (S136), 1–517. https://doi.org/10.4039/entm118136fv

Lofego, A.C. & Feres, R.J.F. (2006) A new genus and species of tarsonemid mite (acari: Tarsonemidae) from Brazil. *Zootaxa*, 1299 (1), 45–55. https://doi.org/10.11646/zootaxa.1299.1.3

Lofego, A.C., Cavalcante, A.C.C., Demite, P.R., Rezende, J.M., Ochoa, R. & De Moraes, G.J. (2019) Reinstatement of *Metatarsonemus* Attiah (Acari: Tarsonemidae), with description of a new species, redefinition of the genus and a key to the world species. *Zootaxa*, 4711 (2), 307–329.https://doi.org/10.11646/zootaxa.4711.2.5

Lofego, A.C., Demite, P.R. & De Moraes, G.J. (2015) A new genus and species of Tarsonemidae (acari: Heterostigmata) from the Atlantic Forest, Brazil. *Zootaxa*, 3986 (5), 561–568. https://doi.org/10.11646/zootaxa.3986.5.3

Mondal, P. (July 28, 2022) *Taxonomy and diversity of Tarsonemini Canestrini and Fanzago, 1877 (Acari: Tarsonemidae) mites associated with economically important plants of West Bengal* [Doctoral Thesis]. Bidhan Chandra Krishi Viswa Vidyalaya. 226 p.

Mondal, P. & Karmakar, K. (2021a) A new genus *Bongotarsonemus* with two new species of tarsonemid (Acari: Heterostigmata) mites discovered from the Himalayan forests of West Bengal, India. *Zootaxa*, 5072 (6), 575–591. https://doi.org/10.11646/zootaxa.5072.6.5

Mondal, P. & Karmakar, K. (2021b) Taxonomic notes on genus Floridotarsonemus (Acari: Tarsonemidae) with a description of two new species from West Bengal, India and keys to the world species. *Systematic and Applied Acarology*, 26 (6), 1109–1125. https://doi.org/10.11158/saa.26.6.8

Mondal, P. & Karmakar, K. (2021c) First record of Fungitarsonemus (Acari: Tarsonemidae) from India with description of three new species from the state of West Bengal. *Systematic and Applied Acarology*, 26 (11), 2027–2047. https://doi.org/10.11158/saa.26.11.4

Mondal, P. & Karmakar, K. (2021d) First record of *Metatarsonemus* (Acari: Tarsonemidae) from India with description of two new species. *Zootaxa*, 4942 (2), 229–251. https://doi.org/10.11646/zootaxa.4942.2.6

Mondal, P. & Karmakar, K. (2022) A New species of *Daidalotarsonemus* from Eastern India with complementary description of *D. duolamella* Lin, Chen & Zhang, 1998 (Acari: Tarsonemidae) and keys to the Oriental species. *Biologia* (in press).

Mondal, P., Ganguly, M. & Karmakar, K. (2021a) Three new species of Metatarsonemus (Acari: Tarsonemidae) from a part of Central Himalayan biotic province in West Bengal, India. *International Journal of Acarology*, 47 (7), 610–627. https://doi.org/10.1080/01647954.2021.1976274

Mondal, P., Ganguly, M. & Kayal, S. (2022) A new species of *Xenotarsonemus* (Acari: Tarsonemidae) from West Bengal, India with keys to the Asian species. *Systematic and Applied Acarology*, 27, 1888–1900. https://doi.org/10.11158/saa.27.10.4

Mondal, P., Ganguly, M., Karmakar, K. & De Moraes, G. Jd. (2021b) Two new species of *Tarsonemus* (Acari: Tarsonemidae) from the Indo-Gangetic plains of West Bengal, India, with brief notes on their bioecology. *Journal of Natural History*, 55 (41–42), 2569–2588. https://doi.org/10.1080/00222933.2021.2001600

Moser, J.C., Konrad, H., Blomquist, S.R. & Kirisits, T. (2010) Do mites phoretic on elm bark beetles contribute to the transmission of Dutch elm disease? *Naturwissenschaften*, 97 (2), 219–227. https://doi.org/10.1007/s00114-009-0630-x

Ochoa, R. & Oconnor, B.M. (1998) Two new species of the genus *Excelsotarsonemus* (Acari: Tarsonemidae). *International Journal of Acarology*, 24 (3), 179–187. https://doi.org/10.1080/01647959808683583

Oksanen, J., Blanchet, F.G., Kindt, R., Legendre, P., Minchin, P.R., O'Hara, R.B., Simpson, G.L., Solymos, P., Stevens, M.H.H. & Wagner, H. (2017) *Vegan: Community Ecology Package*. R Package Version 2.2-0., http://CRAN.Rproject.org/package=vegan

Sanyal, A.K., Alfred, J.R.B., Venkataraman, K., Tiwari, S.K. & Mitra, S. (2012) Status of biodiversity of West Bengal. *Zoological Survey of India*. Kolkata, India. 969 p.

Sousa, A.S.G., Rezende, J.M., Lofego, A.C., Ochoa, R. & Oliveira, A.R. (2018) *Daidalotarsonemus* and *Excelsotarsonemus* species (Acari: Tarsonemidae) found in shaded cacao plantations in Brazil, with a description of a new species. *International Journal of Acarology*, 44 (2–3), 68–79. https://doi.org/10.1080/01647954.2018.1471096

R Core Team, (2013) *R*: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. *https://www.R-project.org*

Shannon, C.E. (1948) A mathematical theory of communication. *The Bell System Technical Journal*, 27, 379–423. https://doi.org/10.1002/j.1538-7305.1948.tb01338.x

Walter, D.E. & Proctor, H.C. (2013). Mites and biological diversity. In: Walter, D.E. & Proctor, H.C. (eds) *Mites: Ecology, Evolution & Behaviour*. Springer, Dordrecht, pp. 447–459.

تنوع و تخصص میزبانی کنه‌های قبیله Tarsonemini (Acari, Tarsonemidae) – تحقیق و بررسی در نواحی اگروکلیماتیک بنگال غربی، شرق هند

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چکیـده: تعداد زیادی از کنه‌های مناطق گرمسیری و نیمه گرمسیری متعلق به خانواده Tarsonemidae Canestrini & Fanzago, 1877، متعلق به قبیله Tarsoenmini از زیرخانواده Tarsoneminae دارای تنوع بسیار زیاد هستند. به منظور درک بهتر توزیع، ساختار جمعیتی و تخصص میزبانی این کنه‌ها، بررسی فون این کنه‌ها در هند، به ویژه در ایالت بنگال غربی، اهمیت زیادی دارد. در مجموع ۱۱۵۴ نمونه کنه از ۶۹ گونه گیاهی، متعلق به ۴۴ خانواده با توزیع در شش منطقه اگروکلیماتیک در بنگال غربی به دست آمد. کنه‌ها در ۸ جنس مجزا و ۳۸ گونه ریختی، طبقه‌بندی شدند. شبکه‌های تغذیه‌ای دوبخشی ویژه کنه‌های Tarsoenmini برای اولین بار توسعه داده شد تا از این طریق چگونگی ارتباط جمعیت‌های این کنه‌ها با گونه‌های مختلف گیاهان میزبان در شش منطقه مختلف کشاورزی نشان داده شود. توصیفگرهای مختلف شامل اتصال، *H2*، همپوشانی بنیچه و ثبات شبکه‌های ارتباطی کنه – گیاه میزبان در شش منطقه اگروکلیماتیک محاسبه شد. منطقه واقع در بلندهای شمالی بیشترین تنوع را داشت و پس از آن مناطق آبرفتی و تیستا-ترای مشخص شدند، در حالی‌که کمترین تنوع گونه‌ای در منطقه خاک‌سرخ دیده شد. بیش از ۷۰ درصد کنه‌های Tarsoenmini به‌عنوان گونه‌های عمومی روی گیاهان شناخته شدند و این موضوع با رویه تغذیه سطحی از عناصر میکروبی مطابقت دارد.

واژگـان کلیدی: شبکه‌های تغذیه‌ای دوبخشی، تنوع زیستی، ساختار جمعیت، محافظت، پراکنش، اکوسیستم، کنه