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**RESEARCH ARTICLE**

# DIVERSITY, DISTRIBUTION AND HABITAT PREFERENCE OF PREDACIOUS COCCINELLIDS (COLEOPTERA: COCCINELLIDAE) IN AGRO- AND FOREST HABITATS OF TRIPURA, NORTHEAST INDIA

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**ABSTRACT**

The diversity of predacious Coccinellids is of great practical and scientific importance due to their worldwide utilization as natural enemy of phytophagous insect pests. Present inventory was carried out in two types of habitats namely, agro- and forest habitats for predacious coccinellids in Tripura, northeast India. Random collection was made by hand picking and sweep netting during January 2008 to December 2010. A total of 1627 individuals of coccinellids representing 24 species under 17 genera were collected. Overall rank distribution of species based on relative abundance showed that 24 species distributed in 21 ranks. Diversity indices, richness estimate and individual based rarefaction curve revealed that species richness and diversity of coccinellids was more in forest habitats than the agro-habitats.



## INTRODUCTION

Tropical rainforests are one of the most species-rich and functionally important terrestrial ecosystems (Myers *et al*., 2000). An estimated 32% of these tropical rainforests have been converted to human-dominated systems in past 50 years (Millenium Ecosystem Assessment, 2005). As a result, recently, focus and interests of scientists, conservationists and ecologists shifted towards managed agricultural areas (Donald, 2004; McNeely, 2004) along with natural forest ecosystems for biodiversity conservation of existing flora and fauna. Insects represent a dominant component of biodiversity in most terrestrial ecosystems and play a significant role in the ecosystem functioning (Weisser and Siemann, 2004).Among the predatory insects, Coccinellids are one of the most economically important groups, and, are very widespread in agricultural and forest ecosystems. Both larvae and adults of coccinellidae (excluding most of the members of the subfamily Epilachninae) are well known for their aphido- and coccidophagous nature.

They solely feeds on a number of distantly related phytophagous insect pests of the agricultural and horticultural crops (Omkar and Pervez, 2000; Hodek and Honek, 1996), and some are very prey specific and habitat specialist. Several studies reported that most of the species showed high feeding potential, foraging activity and reproductive efficiency, which are the characteristics of effective biocontrol agent used in IPM (Fernandez-Arhex and Corley, 2003; Kohno, 2003). With regard to biodiversity, the significance of predacious coccinellids lies in the fact that they keep the prey population under control, thereby contribute to the maintenance of the ecosystem balance because control of natural pest reduces dependence on chemical pesticides, which are considered harmful to environment and promote resistance in pests (Murdoch, 1975).

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Predacious coccinellids are also useful as bio-indicators and can provide more general information about the ecosystems health in which they inhabit. The family comprises about 5200 described species worldwide (Hawkeswood, 1987), of which about 90% of the species of this family are beneficial predators (Iperti and Paoletti, 1999). In contrast, 400 species under 79 genera belongs to 22 tribes and five subfamilie was known from Indian subregion as a whole (Poorani, 2002), and in particular from northeast India, 8 species was reported from Nagaland, 38 species from Manipur, 16 species from Mizoram, 49 species from Meghalaya and 35 species from Arunachal Pradesh (Shantibala and Singh, 1991; Singh and Singh, 1991; Chakraborty and Biswas, 2000; Chakraborty, 2004; Hemcahandra *et al*., 2010). However, perusal of literature revealed that previous studies documented 36 species from the state of Tripura (Agarwala and Ghosh, 1984; Chaktaborty and Biswas, 2002) without regard to their diversity pattern and habitat preferences. In this regard, an attempt has been made to document the hitherto unknown diversity pattern of coccinellids in agro- and forest ecosystems of Tripura, northeast India.

## MATERIALS AND METHOD

### Study Area

Tripura is geographically lies between 22° 56′ to 24°32′ N and 91°10′ to 92° 21′ E (Fig. 1), and an integral part of the Indo-Burma biodiversity hotspot and thus occupies a critical position in the global biodiversity scene (Myers *et al*., 2000). Tripura is known for its rich biological resources due to availability of various ecological niches and habitats ranging from hilly terrain with undulating slopes, plains and valleys dominated by semi-evergreen to moist deciduous forests and secondary bamboo brakes which in turns support diverse faunal communities. The important vegetation types of managed agro-ecosystems comprising of paddy, banana, pineapple, seasonal

**Table 1. Geo-coordinate position and vegetation characteristics of the study sites [agro- (A) and forest (F)] of Tripura**

| Study site | Geographical position | Altitude (m) asl. | Vegetation structure and anthropogenic disturbance |
|---|---|---|---|
| Debbari (F) | N 23°32.053′ E 91°36.598′ | 35 m | Dominated by mature secondary moist deciduous riparian woody forests along with several bamboo species, flowering herbs and shrubs. Presence of moderate sign of anthropogenic pressures is evident. |
| Baramura (F) | N 24°4.05′ E 91°44.39′ | 462 m | Dominated by vascular woody plants and bamboos representing secondary mixed-moist deciduous forests. Plantation of *Tectona grandis* L. trees along road sides and citrus plant in the valley were also found. Anthropogenic pressures are moderate. |
| Saikabari (F) | N 24°6.45′ E 91°53.15′ | 368 m | Mature mixed moist deciduous secondary forests. Logging, shifting cultivation, bamboo extraction, grazing by domestic cattle is found to be frequent. |
| Jampuihills (F) | N 23°48.645′ E 92°15.682′ | 837 m | Semi-evergreen moist forests along with under storey herb, shrub, epiphytes, orchids and bamboo of different kinds. Most of the forests are now fragmented due to shifting cultivation by ethnic tribes. |
| Bagabasa (A) | N 23°45.652′ E 91°15.958′ | 766 m | Agricultural area surrounded by patches of fragmented secondary forests. Paddy is the dominant crop and other seasonal crops and vegetables are also cultivated. Excessive use of chemical fertilizers and pesticides are the major threats. |
| Shanmura (A) | N 23°50.54′ E 91°15.08′ | 12 m | Intensively managed agricultural area dominated by paddy and other seasonal crops and vegetables with patches of natural vegetation. |
| Halhali (A) | N 24°6.18′ E 91°49.16′ | 78 m | Agricultural area mostly dominated by paddy, seasonal vegetables, and patches of *Tectona grandis* and *Hevea brasiliensis* plantations. Use of chemical pesticides, fertilizers and soil erosion are major threats. |
| Kailasahar (A) | N 24°15.57′ E 91°57.49′ | 34 m | Managed agricultural land dominated by seasonal crops. Patches of herbs and shrubs at the periphery of agro-ecosystem are also present. Few patches of afforested *Tectona grandis* and *Areca catechu* plants are other features. |

**Table 2. List of coccinellid species recorded in agro- and forest ecosystems of Tripura**

| Zoological name | No. of specimens collected in ecosystems | | Relative abundance (%) | Species rank |
|---|---|---|---|---|
| | Agro | Forest | | |
| *Micraspis discolor* (F.) | 203 | 196 | 24.52 | 1 |
| *Cheilomenes sexmaculatus* (F.) | 193 | 102 | 18.13 | 2 |
| *Coccinella transeversalis* F. | 89 | 106 | 11.99 | 3 |
| *Coccinella septempunctata* L. | 80 | 73 | 9.40 | 4 |
| *Scymnus latemaculatus* Motschulsky * | 66 | 43 | 6.70 | 5 |
| *Anisolemnia dilatata* (F.) $^{+}$ | 0 | 76 | 4.67 | 6 |
| *Scymnus* sp. | 30 | 38 | 4.18 | 7 |
| *Harmonia octomaculata* (F.) * | 24 | 22 | 2.83 | 8 |
| *Brumoides suturalis* (F.) $^{-}$ | 45 | 0 | 2.77 | 9 |
| *Synonycha grandis* (Thunberg) * | 27 | 11 | 2.34 | 10 |
| *Micraspis univittata* (Hope) * | 32 | 2 | 2.09 | 11 |
| *Chilochorous nigrita* (F.) $^{-}$ | 28 | 0 | 1.72 | 12 |
| *Cryptogonus quadriguttatus* (Weise) * | 25 | 2 | 1.66 | 13 |
| *Chilochorous circumdatus* Schonherr * | 6 | 17 | 1.41 | 14 |
| *Coelophora saucia* (Mulsant) $^{+}$ | 0 | 19 | 1.17 | 15 |
| *Cryptogonus postmedialis* Kapur * | 4 | 13 | 1.04 | 16 |
| *Oenopia kyrbyi* Mulsant * $^{+}$ | 0 | 17 | 1.04 | 16 |
| *Coelophora bisellata* Mulsant | 7 | 4 | 0.68 | 17 |
| *Cryptolaemus montrouzieri* Mulsant * | 3 | 3 | 0.37 | 18 |
| *Pseudaspidimerus* sp. $^{+}$ | 0 | 6 | 0.37 | 18 |
| *Harmonia dimidiata* (F.) * $^{-}$ | 5 | 0 | 0.31 | 19 |
| *Harmonia sedecimnotata* (F.) * $^{+}$ | 0 | 4 | 0.25 | 20 |
| *Illeis* sp. $^{-}$ | 3 | 0 | 0.18 | 21 |
| *Rodolia* sp. * $^{+}$ | 0 | 3 | 0.18 | 21 |

Symbol denotes: * new record from the state, + Forest habitat, - Agro-habitat

**Table 3. Diversity parameters and species richness estimates values of predatory coccinellids in agro- and forest ecosystems**

| Habitat | Shannon diversity (*Hs*) | Simpson's dominance (*Dm*) | Pilou evenness (*J'*) | Chao 2 | Observed species richness | *Sampling completeness (%) |
|---|---|---|---|---|---|---|
| Agro-ecosystem | 2.30 | 0.14 | 0.80 | 20 | 18 | 90 |
| Forest ecosystem | 2.33 | 0.13 | 0.78 | 28 | 20 | 71 |
| Overall | 2.43 | 0.13 | 0.77 | 27 | 24 | 89 |

*Sampling completeness = [(Observed species no./Estimated species no.) **x** 100]

vegetables and plantation crops such as arecanut, coconut, rubber etc. To some extent orange orchards, Parkia javanica Lam. and coffee plantations are also present in hilly parts of the state. It shares about 0.3% of the total geographical area of the country. Tropical climatic conditions prevail in Tripura with the annual rainfall of about 2100 mm due to southwest monsoon. Temperature ranges between 10°C to 36°C, with altitudes varying from 15 to 850 m above sea level.

## Field Study

Present inventory was carried out in two major types of habitats namely, agro- and forest ecosystems for predacious coccinellids during January 2008 to December 2010. Of the habitats, four locations namely, Debbari, Baramura, Saikabari, Jampuihills are forested habitats and Bagabasa, Shanmura, Halhali, Kailasahar are agriculture dominated areas (Table 1). The degree of anthropogenic pressure is distinct among the eight study sites. Collections of insects were made randomly by hand picking and sweep netting, once in a month at each study sites. Collected specimens from each study sites were treated separately and preserved manually in Ecology and Biodiversity laboratories of Tripura University. Most of the collected specimens were identified up to species level and few of the specimens are identified up to genera level with the help of available

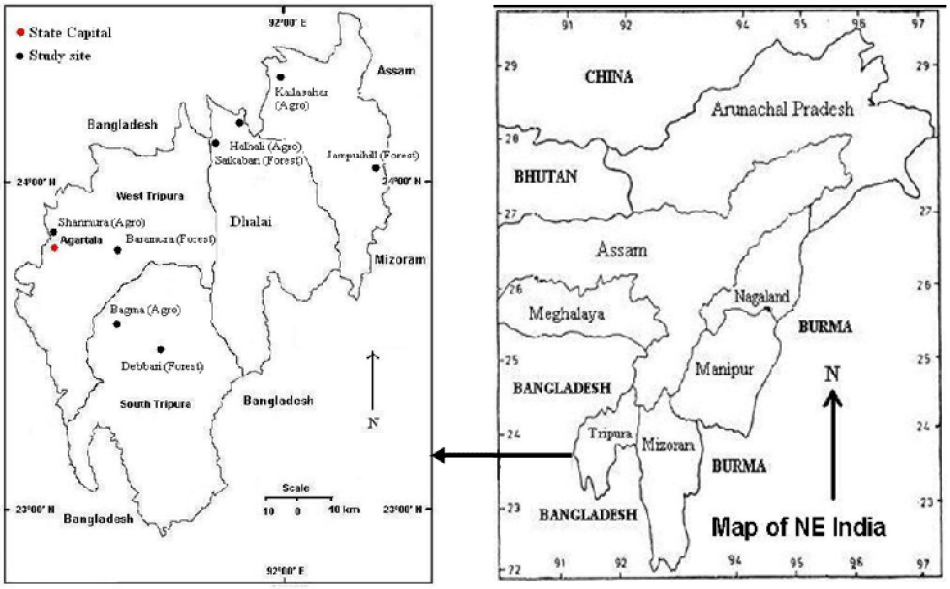


**Figure 1. Map of Tripura showing study sites**

keys (Omkar and Bind, 1993, 1995, 1996; Omkar and Pervez, 1999; Poorani, 2002). vegetables and plantation crops such as arecanut, coconut, rubber etc. To some extent orange orchards, Parkia javanica Lam. and coffee plantations are also present in hilly parts of the state. It shares about 0.3% of the total geographical area of the country. Tropical climatic conditions prevail in Tripura with the annual rainfall of about 2100 mm due to southwest monsoon. Temperature ranges between 10°C to 36°C, with altitudes varying from 15 to 850 m above sea level.

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### Data Analysis

Raw data of this study was subjected to statistical analysis to calculate overall Shannon diversity, Simpson's dominance and Pielou evenness index and also separately for agro- and forest ecosystems (Magurran, 1988). To compare the diversity of agro- and forest ecosystems statistically t-test analysis was performed. Species recorded in this study were ranked based on relative abundance of individual species. Second order Chao (Chao 2) species richness estimate was used to determine the expected number of species. Sampling completeness was calculated as ratio of observed species richness to the value of estimated species richness and expressed as percentage. Raw data of species richness counts of two years from agro- and forest sites were pooled to get rarefaction curves for comparison of estimated species richness between the major habitats. PAST version 2 (Hamer *et al*., 2001) was used to determine diversity indices and Biodiversity Pro version 2 (Lambshead *et al*., 1997) was used to determine rarefaction curves. Rank abundance diagram and t-test analysis were performed by Origin version 5 (Micrococal Software, Inc.).

## RESULTS AND DISCUSSION

### Diversity pattern

A total of 1627 individuals of predacious coccinellids belonging to 24 species under 17 genera were recorded from different agro- and forest habitats of Tripura state during the study period (Table 2, 3). The 24 species recorded in the present study can be compared satisfactorily with the 35 species recorded in another study at Arunachal Pradesh, northeast India (Hemchandra *et al*., 2010) that showed more or less similarity in habitats and climatic conditions. Of the 24 species recorded, 18 species (75.00%) and 20 species (83.33%) was collected from the agro- and forest habitats, respectively. Fourteen species (58.33%) was shared by both habitats and the similarity value is 0.62. High similarity value of predacious coccinellids fauna between these two habitat types indicates that most of the recorded species are generalist species, and, more or less evenly utilize prey species of both habitats. Out of 24 species, 10 species (41.67%) has been recorded from only a single habitat type, and hence, considered as unique species. Agro- and forest habitats contain four [*Brumoides suturalis* (F.), *Chilochorous nigrita* (F.), *Harmonia dimidiata* (F.), *Illeis* sp.) and six [*Anisolemnia dilatata* (F.), *Coelophora saucia* (Mulsant), *Oenopia kyrbyi* Mulsant, Pseudaspidimerus sp., *H. sedecimnotata* (F.), *Rodolia* sp.] unique species, respectively. Habitatwise diversity analysis showed that forest ecosystem was more diverse in terms of coccinellids diversity (*Hs* = 2.33), dominance (*Dm* = 0.13) and evenness (*J'* = 0.78) than agro- ecosystems (*Hs* = 2.30), dominance (*Dm* = 0.14) and evenness (*J'* = 0.80), respectively (Table 3). Results suggested that the more structural diversity in terms of vegetation in forested habitats might facilitate a definite set of micro habitats for a particular species, and hence, increases the number of unique species compare to managed agro-ecosystems. However, statistical analysis showed non-significant differences ($t$= 0.62, $p$= 0.53) between the coccinellids diversity of these two broad habitat types. Twelve species (50.00%) viz., *Scymnus latemaculatus* Motschulsky, *H. octomaculata* (F.), *H. dimidiata* (F.), *H. sedecimnotata* (F.), *Synonycha grandis* (Thunberg), *Micraspis univittata* (Hope), *Cryptogonus quadriguttatus* (Weise), *Chilochorous circumdatus* Schonherr, *Cryptogonus postmedialis* Kapur, *Oenopia kyrbyi* Mulsant, *Cryptolaemus montrouzieri* Mulsant and *Rodolia* sp. were recorded first time from the state (Table 2).

### Species ranking

Overall ranking of 24 coccinellid species according to their relative abundance showed that these were distributed into 21 ranks. *Micraspis discolor* (F.), *Cheilomenes sexmaculatus* (F.) and *Coccinella transeversalis* F. showed maximum population and Coccinella transeversalis F. showed maximum population and occupied ranks 1, 2 and 3, respectively, having relative abundance of 24.52%, 18.13% and 11.99%, respectively. Next 14 species are ranked between 4 and 16 with abundance range of 9.40% to 1.04%, and they together accounted 43.02% of total abundance. Remaining 7 species are ranked between 17 and 21 and together accounted 2.34% of total abundance (Table 2; Fig. 2). High abundance of *Micraspis discolor* (F.), *Cheilomenes sexmaculatus* (F.) and *Coccinella transeversalis* F. is obvious because these species are generalist in their feeding habit and are known to maintain their population throughout the year (Agarwala and Ghosh, 1984; Agarwala and Yasuda, 2000; Omkar and Bind, 2004; Omkar and James, 2004).

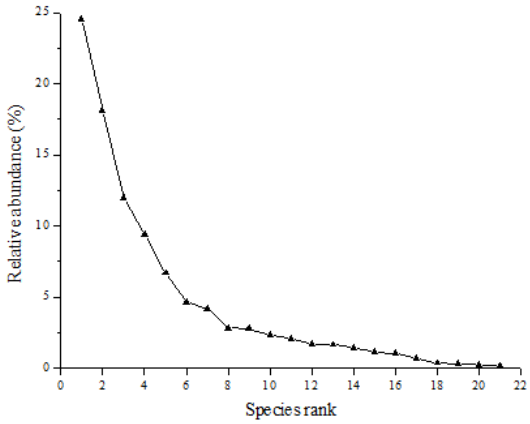


**Figure 2. Rank abundance diagram showing distribution of predacious lady beetles in Tripura, northeast India**

### Richness estimates

The incidence-based Chao 2 estimator provided the most reliable estimates of species richness in this study. Average value of estimation of species richness in the two habitats showed that expected species richness (27 species) is very close to the observed species richness (24 species). The sampling efficiency ranged from 71 % to 90 % between the habitats and showed an overall sampling completeness of 89 % (Table 3). However, Coddington *et al*. (1996) stated that estimates are indicator of species richness which could be an underestimate of the true total richness of the area. An individual based rarefaction curve is used for β-diversity study between studied habitats (Ramesh *et al*., 2010).

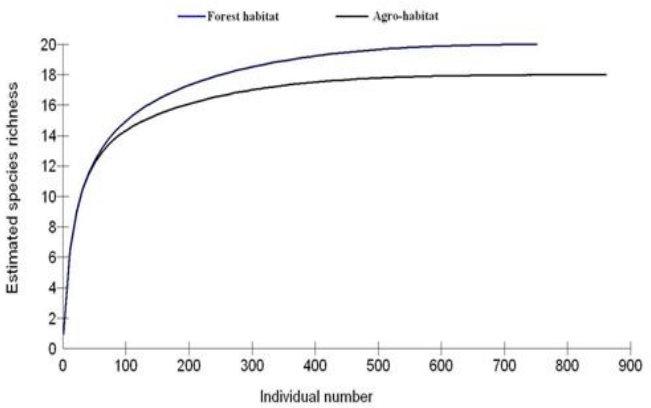


**Figure 3. Individual based rarefaction curve showing the estimated species richness of predacious coccinellids in agro- and forest habitat**

Rarefaction curves of the two habitat types showed quick rise at first and then level off. Nonetheless, rarefaction curve of forest habitat showed saturation of species richness at high individual abundance in comparison to agro-habitats. This in turn indicates that moderate to least disturbed forested ecosystems influenced coccinellids species richness which is evident from the more number of unique species recorded in the forest habitat compare to agro-habitats (Fig. 3)

### Conclusion

This is the first quantitative assessment of predacious coccinellids in the state of Tripura, northeast India. According to the result 24 different species belonging to 17 genera was recorded in this study. Comparison of abundance, species richness and diversity indices between agro- and forest habitats revealed that coccinellid diversity and conservation potential was more in forest ecosystems than the intensively managed agro-ecosystems. Therefore, it can be suggested that forest habitats can act as important natural habitats of coccinellid predators, which may contribute to the occurrence of ladybird predators in agro-habitats. Moreover, six species occurred exclusively in forest habitats and four species in agro-habitats can be used as bioindicator species to evaluate the overall health of forest habitats in Tripura state in particular and northeast region as a hole.

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