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BIODIVERSITY OF EARTHWORMS IN THE SOILS UNDER RUBBER PLANTATIONS IN TRIPURA

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In spite of the monoculture nature of the plantations, rubber (*Hevea brasiliensis*) plants offer an ecofriendly environment for soil flora and fauna. The dense canopy of the rubber plants provides shade and conserves soil moisture. This makes the soil hospitable to soil microarthropods and earthworms which play a major role in soil fertility, ecosystem function and production. Rubber plantations in Tripura showed the presence of 20 species of earth worms. Interestingly, rubber plantations show high indices of dominance and low species diversity of earthworms and soil microarthropods as compared to that of the mixed forest. Being an exotic earthworm with its origin in Brazil, *Pontoscolex corethrurus* represents 61 per cent biomass and 72 per cent density of total earthworm population in the rubber plantation.

Key words: Biodiversity, Earthworms, Microarthropods, Monoculture, Nematodes, Rubber.

INTRODUCTION

Soil microorganisms are an integral part of agricultural and forestry ecosystems and play a critical role in maintaining soil health, ecosystem functions and production. Soil biodiversity reflects the variability among living organisms in the soil ranging from the myriad of invisible microbes to the more familiar macrofauna such as earthworms and termites. A biodiversity crisis has arisen recently due to the dramatic loss of species, habitats and ecological interactions.

Raising a forest plantation is the most widely adopted method to restore the fragile ecology of forests that have been denuded for various purposes, including shifting cultivation (*jhumming*), in the north-eastern region of India. *Hevea brasiliensis* is endemic to Amazon rain forests and the tree has all the attributes of a forest tree species. It was introduced into Tripura in 1963 by the Forest Department to check soil degradation due to slash and burn agriculture practiced by the local tribal people and also as a part of their rehabilitation programme. Rubber has become an important cash crop in the economy of Tripura where it occupies more than 33,000 ha of land. Being deciduous, it shows leaf fall during February – March, with an annual litter addition of 7 t/ha to the plantation floor (Jacob, 2000). *Hevea* leaf litter has been reported to be a good substrate for growth and reproduction of South African vermicomposting worm, *Eudrilus eugeniae* (Chaudhuri *et al.*, 2003). Comparative studies on soil biodiversity in rubber (*H. brasiliensis*) plantations with other forestry plantations or natural forests are sparse (Bhattacharya *et al.*, 1985). Studies on ecology and biodiversity in rubber plantations in

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Tripura gain importance due to the dramatic increase in plantation areas by this exotic plant species which necessitates an understanding of its impact on native soil fauna and flora. In this context a survey was conducted on the diversity of earthworm species in rubber plantations in Tripura and is reported

METHODOLOGY

Earthworm estimation was carried out in 200 random samples obtained by digging (25x25x30 cm soil volumes) and hand sorting method, from rubber plantations of subdivisions (Sonamura, Bishalgarh, Sadar, Khowai, Udaipur, Belonia, Kailashahar, Dharmanagar, Kamalpur and Longtarai valley) of Tripura. Physico-chemical properties of the soils *viz.*, soil texture, temperature, moisture, pH, organic matter and water holding capacity of rubber plantations were compared with mixed forests in WestTripura by standard methods. Biosynecological parameters like earthworm density, biomass, species richness index, Shannon diversity index, index of dominance and species evenness of both the soils were also calculated.

RESULTS

The survey revealed the presence of 20 species of earthworms belonging to 10 genera and 5 families in the rubber plantations in Tripura. These are Octochaetidae [*Eutyphoeus gigas* Stephenson, *Eutyphoeus gammiei* (Beddard), *Eutyphoeus comillahnus* Michaelsen, *Eutyphoeus assamensis* Stephenson, *Eutyphoeus festivus* Gates, *Eutyphoeus* sp 1, *Dichogaster bolaui* Stephenson, *Dichogaster affinis* Michaelsen, *Lenogaster chittagongensis* Stephenson, *Octochaetona beatrix* Gates], Megascolecidae [*Metaphire houlleti* (Perrier), *Perionyx* sp 1, *Kanchuria sumerianus* Julka, *Kanchuria* sp 1, *Kanchuria* sp 2], Moniligastridae [*Drawida nepalensis* Michaelsen, *Drawida papillifer papillifer* Gates

Table 1. **A comparison between some physico-chemical properties of the soils and some biosynecological parameters of rubber plantations and mixed forests in West Tripura**

Edaphic parameters	Rubber plantation (Mean ± SE)	Mixed forest (Mean ± SE)	t-value	P-value
Soil texture	Sandy loam	Sandy clay loam		
Temperature (°C)	27.07 ± 0.06	27.02 ± 0.08	0.45	0.657
Moisture (%)	23.84 ± 0.71	22.83 ± 0.73	0.97	0.334
pH	4.51 ± 0.07	4.62 ± 0.06	1.14	0.259
Organic matter (%)	1.36 ± 0.09	1.40 ± 0.04	0.40	0.693
Water holding capacity (%)	36.69 ± 0.94	36.97 ± 0.54	0.27	0.792
Earthworm density (ind./ m^2)	115.41 ± 10.83	69.01 ± 4.97	3.80	0.0003 *
Earthworm biomass (g/ m^2)	45.91 ± 3.69	45.24 ± 3.48	0.13	0.897
Species richness index	0.45 ± 0.06	0.57 ± 0.03	1.70	0.17
Shannon diversity index	0.86 ± 0.22	1.76 ± 0.04	4.03	0.016 *
Index of dominance	0.62 ± 0.12	0.20 ± 0.01	3.40	0.03 *
Species evenness	0.41 ± 0.10	0.83 ± 0.01	3.88	0.018 *

*Significant ($P \leq 0.05$)

and *Drawida assamensis* Stephenson], Glossoscolecidae [*Pontoscolex corethrurus* (Muller)] and Ocnerodrilidae [*Gordiodrilus elegans* Beddard].

In the rubber plantations, the mean soil temperature was 27°C, soil moisture was 24 per cent, pH was 4.5 and organic matter content was 1.3 per cent (Table 1). Density and biomass of earthworms increased significantly with increase in age of rubber plantations (Chaudhuri and Bhattacharjee, 2008). Surprisingly exotic species of earthworm, *Pontoscolex corethrurus* (Phylum: Annelida, Class: Oligochaeta, Order: Haplotaxida, Family: Glossoscolecidae) accounted for this increase in density and biomass. Mean values for density and biomass of earthworms in rubber plantations were 115 individuals and 46 g per square metre. The exotic earthworm, *P. corethrurus* (Fig. 1) was the dominant species in rubber plantations representing 61 per cent biomass and 72 per cent density of the total earthworm population. In spite of the large quantity of litter fall annually on the plantation floor, the *H. brasiliensis* agro-ecosystem is largely dominated by geophagous (endogeic) species of earthworms like *P. corethrurus*. In contrast, litter (epigeic) and phytogeophagous (anecic) species of earthworms formed a minor

Fig. 1. The most dominant earthworm species, *P. corethrurus* from rubber plantations in Tripura

component. This may be due to the low palatability of leaf litter of *H. brasiliensis* due to its high phenolic contents.

Mean earthworm density in the rubber plantations (115±10 ind./ m^2) was significantly higher ($p<0.01$) than that in the mixed forest (69±4 ind./m^2), but mean earthworm biomass in both the study sites (rubber plantation 46±3 g/m^2, mixed forest 45±3 g/m^2) did not show any significant difference. This was because the exotic species *P. corethrurus* showed comparatively higher density in the rubber plantation (88 ind./ m^2) than in the mixed forest (19 ind./m^2) which accounted for significantly higher mean density values of earthworms in the rubber plantation. On the other hand, large sized worms, most of which are native species, like *Eutyphoeus gigas*, *Kanchuria*. and *Eutyphoeus comillahnus* being relatively more abundant in the mixed forest than in the rubber plantation, contributed greater biomass to the mixed forest. Index of dominance was significantly higher and diversity index and species evenness (Ismail *et al.*, 1990) were significantly lower in rubber plantations when compared with mixed forests.

DISCUSSION AND CONCLUSION

Rubber plantations in Tripura are hospitable to a large number of species of plants, nematodes, earthworms, ants, collembola, mites etc. (Bhattacharya and Chakraborti (1995); Mukherjee *et al.*, 2000 and Chakraborty *et al.*, 2002). In spite of less palatability and slow rate of decomposition of rubber leaf litter, soil biodiversity is not affected to a great extent. This is due to the thick canopy of rubber plantation that curtails solar radiation, protects surface soil from the thrust of rain, reduces air temperature, allows moisture conservation and retains organic carbon. As the top soil contains an extensively distributed and horizontally placed root mesh, nutrients derived from decomposition of leaf litter are utilized by the plants themselves and to some extent by the below-ground soil biota. So the topsoil of rubber plantation never contains a rich nutrient pool. However, suitable temperature, moisture, aerobicity etc. of the top soil create favourable microclimatic conditions for soil dwelling organisms.

Anthropogenic influences like tapping and clearing of weed growth create a harsh environment in the rubber plantation that leads to dominance of only one or two species of plants or animals in a particular community. Dominance shared by a number of species in a community is a characteristic feature of mixed forest. Indeed mixed forests provide heterogeneous food source for soil biota and thus create suitable environment for greater biodiversity. Monoculture crops like rubber plantations provide only a restricted ecological niche and thereby offer less biodiversity.

Importance of a species in a community and the role played by it can be analyzed with the help of dominance index. According to Karr (1971), dominance index for avifauna increases with the increase in harshness of the environment and decreases with vegetational development. Higher dominance index in rubber plantations as compared to mixed forest indicates that the rubber plantation probably offers a comparatively harsher environmental condition, so that the functional importance has been concentrated on only one or two species. The relative harshness of the environment in rubber plantations might have been due to the human interference in the form of forest clearing and burning carried out by the shifting cultivation prior to rubber planting and tapping and other cultural operations now undertaken in rubber plantations.

Earthworm account for the highest biomass among tropical soil macrofauna. Due to their peculiar mode of feeding, burrowing and casting activity, earthworms improve the physico-chemical status of the soil and thereby support above–ground vegetation. Earthworms are well known as a bio-indicator of soil health (Chaudhuri, 2005). Density and biomass of earthworms increased significantly with increase in age of rubber plantations (Chaudhuri and Bhattacharjee, 2008).

Earthworms communities of rubber plantations are composed of 15 endemic and 5 exotic species (Chaudhuri *et al.,* 2008). Exotic species include *P. corethrurus, Metaphire houlleti, Dichogaster bolaui, D. affinis* and *Gordiodrilus elegans.* It is known that exotic species occur and often dominate in disturbed sites (Hendrix and Bohlen, 2002). So occurrence of exotic species in rubber plantation with harsher environment is not surprising. *P. corethrurus,* the commonest earthworm species of Brazil, is the most widely distributed earthworm of the world. Brazil is also the centre of origin of rubber. Dispersal of *P. corethrurus,* (indigenous to north-eastern South America) through exotic crop plants into different parts of the world is quite possible (Chaudhuri *et al.,* 2008). There are also reports on the occurrence of *P. corethrurus,* in rubber plantations of Burma and Malay Peninsula (Gates, 1972). *P. corethrurus,* the dominant species having remarkable population biomass and density in soils under rubber, is a well known soil compacting species. The physical health of soil is determined by the activity of both compacting and decompacting species of earthworms. Dominance of any one type of earthworm may have a deleterious effect on soil physical health. Besides this, it is likely that establishment of exotic species of earthworms may eliminate the native species as has been reported from Peru, Brazil and Mexico. A more detailed survey on the earthworm fauna under different crops and vegetation in denuded/ jhummed forest land may be required for assessment of their relative impact on soil biodiversity (Fragoso *et al.,* 1999).

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