# Large Scale *Hevea brasiliensis* Plantation Impact on Non-Human Primate and Floral Diversity in Khowai District of Tripura

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## ABSTRACT

Over the past three decades, a large proportion of forest area in Khowai district of Tripura has been converted into a rubber plantation (*Hevea brasiliensis*) area. There is less information about the deleterious effect of such changes on non-human primate populations and plant diversity. To address this deficit, line transect and quadrat sampling programs were carried out in Khowai district of Tripura with the purpose of comparing non-human primate species diversity, number of individual primate species observed and also plant species diversity observed in the rubber plantation area and nearby forest area. Less number of non-human primate was observed in the rubber plantation area than in the forest area and individual numbers of tree, shrub and herb species were found to be maximum in the nearby forest area than in rubber plantation area. In shrub layer Shannon and Simpson diversity index were higher in the forest area, whereas in herb layer, Shannon index was lower and Simpson index was higher in rubber plantation area. From this study it was divulge that, rubber plantation have harmful impact on non-human primate and plant species.

**Keywords** Non-human primate, Plant diversity, Line transect, Quadrat sampling, Diversity index.

## INTRODUCTION

Increasing rates of deforestation are particularly problematic in global tropical rainforest, which are home to most of the world's flora and fauna (WWF 2022). Globally more than 80 million hectares of primary forest have declined since 1990, estimates from 2015 to 2020 show that 10 million hectares forest are being deforested every year (The State of the world forest, FAO 2020). Conversion of mature tropical forests to timber plantations (Like as teak, pine) or commercial crops (Like as rubber, oil palm) has reduced habitat for forest-dependent species, and reduced their diversity or abundance and increased fragmentation (Goodale *et al*. 2014, Mandal and Raman 2016). Adverse situations occur when intensive monocultures become overgrown, destroying

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and degrading the habitats of wild plants and animal species (Wilcove *et al.* 2013, Bregman *et al.* 2014, Newbold *et al*. 2014, Mandal and Raman 2016). *Hevea brasiliensis* (Natural Rubber) belongs to the euphorbiaceae family, this plant is a sturdy perennial plant and is native to the tropical rainforests of Central and South America (Bhowmik 2006). Natural rubber plantations are expanding rapidly in Tripura, helping to increase employment and reduce poverty (Sarkar 2011). Our previous study (Patari and Dasgupta 2022) shows that the expansion of rubber plantations in South Tripura is having an adverse effect on the monkey and plants species of this region. Moreover, another research paper claimed that excessive rubber plantations have impact on human health (Truong and Bao 2017). Non-human primate help to maintain ecosystem function and aid in pollination, germination and dispersion of plants (Estrada *et al.* 2017, Marshall and Wich 2016). But when deforestation, shifting cultivation and monoculture plantations increases, drastic changes occur in the life of wildlife. For collecting food, primates move from one area to another and ate seeds, fruits, leaves, bark and gum of various plants. But in monoculture rubber plantations, humans cut down other plants species, as a result primate don't find any food item. Accordingly, it can be hypothesized that human-made environments may lead to lower primate populations and less plant diversity. So, this paper compares non-human primate species diversity and plant species diversity in rubber plantation and adjacent forest areas in Khowai district of Tripura.

## MATERIALS AND METHODS

### Study area

The study was conducted in Khowai district of Tripura, mainly Ramchandraghat forest area, Baramura forest area, Teliamura forest area, Dakhin Moharani area, Uppendranagar village area, Tuiching bari village area, Asharam bari village area, Paschim rajnagar village area, Ghilatali village area and rubber plantation close to them. The study was conducted from November, 2021 to April, 2022. The bio geographic zone of the state belonged to 9B and forest type is comprised of semi-evergreen, moist deciduous, moist mixed deciduous forests and secondary

bamboo brakes (Deb 1981-1983, Majumdar *et al.* 2012). The area of this district is about 1377.28 sq km and the latitude and longitude is $23.8974^0$N and $91.6372^0$E. The climate condition of this district has a monsoon influenced humid subtropical climate with large amounts of rain almost all year. The average annual rainfall in the district is about 2570 mm and the temperature average from $28^0$C (District Environment plan: District Administration Khowai 2022). Generally, rubber plantations cover the vast majority of the areas surrounding these protected forests.

### Non-human primate survey

Twenty-one pairs of forest and rubber plantation sites were sampled. Survey was conducted in the early morning and late afternoon while walking along 2.5 km long transect (observation width using Binoculars 50 m on both sides of the transect laid across each line. In each line transect, primate observed or not was recorded with GPS location; if primate was observed, their identity was confirmed, their numbers were recorded. Each sampling site was positioned at least 150 m to 200 m from the edge of the forest or rubber plantation in order to minimize the sampling of primates foraging on the periphery of both habitats (Patari and Dasgupta 2022).

### Vegetation survey

Vegetation survey was carried in rubber plantation areas and adjacent forest areas in Khowai district of Tripura where ever primates of conservation importance are available. Accordingly quadrats of 20 x 20 m for the tree species (21 paired of forest and rubber tree plantation sites were sampled) and 5 x 5 m plots (42 paired of forest and rubber plantation sites for shrub were sampled) were laid out randomly for sampling shrub layer. To collect information on ground layer and other herbaceous species, quadrats of 1 x 1m size (63 paired of forest and rubber plantation sites for herb and grass was sampled) were laid out within the tree quadrats (Patari and Dasgupta 2022). Analyses the diversity indices and evenness indices of both the study sites and compare it. Plant specimens were collected for proper identification and preservation. The scientific name of the collected plant specimens were identified with the help of The Flora of Tripura

**Table 1.** Distribution of Primate species across the two sectors in adjacent forest area and rubber plantation area in Khowai district of Tripura.

| Species | Number (percentage) | Adjacent forest | Rubber flantation | Total |
|---|---|---|---|---|
| *Macaca mulatta* | N (%) | 236(75.88) | 75(24.11) | 311(100) |
| *Macaca nemestrina* | N (%) | 95 (100) | 0 | 95 (100) |
| *Trachypithecus phayrei* | N (%) | 4 (33.33) | 8(66.66) | 12 (100) |
| Number of individual (Species) | | 335 (3) | 83 (2) | 418 (3) |
| % | | 80.14 | 19.85 | 100 |

State (Deb 1981-1983).The references herbarium was deposited in Conservation Ecology Laboratory, Department of Forestry and Biodiversity, Tripura University.

**Statistical analysis**

T-test was used to compare the number of individual primate per species; number of survey sites where primate observed and total number of primate occurring in both habitats. Species diversity for both the sites was evaluated by Shannon and Weiner (1963), the index of dominance of the community was determined by Simpson (1949) and evenness of the community was calculated by Pielou (1966). All statistical analysis of biodiversity index were determined by using package PAST software 4.03 (Hammer *et al.* 2001). The significance of differences in diversity indices among both the habitat were calculated using t-test in SPSS software (Java 2022).

**RESULTS**

**Primates: Species diversity and abundance**

During the survey, 3 species of non-human primate were observed, among them 2 species are macaque and 1 species is langur. They are *Macaca mulatta, Macaca nemestrina* and *Trachypithecus phayrei* (Table 1). 418 individuals of the 3 species were recorded during this survey (*M. mulatta, M. nemestrina* and *T. phayrei)*. 335 individuals were recorded from adjacent forest areas and 83 individuals were recorded from rubber plantation areas. The largest group was found for the *Rhesus macaque* species. *Trachypithecus phayrei* was found in small groups at rubber plantation site and adjacent forest site and a moderate number of Macaca nemestrina observed only in forested areas.

More than one species was not recorded at the same location and usually only one species was recorded at a time at a location. After t test there is significant difference in distribution of primate species across two sectors in rubber plantation area and adjoining forest area (t=1.751>$t_{0.50}$, $2^{0.82}$ ).

**Habitats of primates**

Primate's population was observed in 14 adjacent forest areas and 4 rubber plantation area out of 42 survey sites, out of 14 adjacent forest areas *Macaca mulatta* recorded in 10 sites, *Macaca nemestrina* and *Trachypithecus phayrei* recorded in 1, 3 survey sites respectively while out of 4 survey sites rubber plantation areas *Macaca mulatta* observed in 3 survey area and *Trachypithecus phayrei* recorded in 1 survey site. Results of the t-test (t=1.64>$t_{0.50}$,$2^{0.82}$) also suggested that primates observed the minimum number of survey sites in rubber plantation areas than the number of survey sites in adjacent forest areas.

Equal line transects sampling of 21 sites in each habitat showed that non-human primate species richness was much higher in adjoining forest than in rubber plantations. The mean number of primate in forest (mean ± SE, 19.95 ± 3.10) was significantly higher than in rubber plantations (mean ± SE, 3.95 ± 2.04) ( t=3.49>$t_{0.05}$, 20 $^{1.72}$).

**Vegetation: Forest tree layer and rubber tree plantation**

Tree layer of the adjacent forest a total of 39 species were recorded in adjacent forest areas. These species belong to 34 genera, 23 families and most of the tree species belonged to moraceae family (4 species) (Table 2). It was observed that the total individual of rub-

**Table 2.** Tree species present in rubber plantation area and adjacent forest area in Khowai district in Tripura.

| Rubber plantation area | |
|---|---|
| Species | Family |
| *Hevea brasiliensis* Mul. Arg. | Euphorbiaceae |

| Adjacent forest area | |
|---|---|
| Species | Family |
| *Shorea robusta* Roth. | Dipterocarpaceae |
| *Microcos paniculata* Linn. | Malvaceae |
| *Glochidion lanceolarium* Voigt. | Phyllanthaceae |
| *Phyllanthus emblica* Linn. | Euphorbiaceae |
| *Lagerstroemia parviflora* Roxb. | Lythraceae |
| *Grewia tiliifolia* Vahl. | Malvaceae |
| *Schima wallichii* (DC.) Korth. | Theaceae |
| *Holarrhena antidysenterica* (Linn.) Wall. | Apocynaceae |
| *Careya arborea* Roxb. | Lecythidaceae |
| *Tectona grandis* L.f. | Lamiaceae |
| *Terminalia bellirica* Roxb. | Combretaceae |
| *Indigofera tinctoria* Linn. | Fabaceae |
| *Callicarpa arborea* Roxb. | Verbenaceae |
| *Streblus asper* Lour. | Moraceae |
| *Sterculia villosa* Roxb. | Malvaceae |
| *Cassia fistula* Linn. | Fabaceae |
| *Dillenia pentagyna* Roxb. | Dilleniaceae |
| *Ficus lamponga* Miq. | Moraceae |
| *Syzygium cumuni* Linn. | Myrtaceae |
| *Bauhinia variegate* Linn. | Fabaceae |
| *Mitragyna rotundifolia* Roxb. | Rubiaceae |
| *Antidesma acidum* Retz. | Phyllanthaceae |
| *Alstonia scholaris* Linn. | Apocynaceae |
| *Oroxylum indicum* Linn. | Bignoniaceae |
| *Vitex altissima* L.f. | Lamiaceae |
| *Gmelina arborea* Roxb. | Lamiaceae |
| *Syzygium fruticosum* DC. | Myrtaceae |
| *Ziziphus jujuba* Mill. | Rhamnaceae |
| *Anogeissus acuminata* Roxb. ex DC. | Combretaceae |
| *Carallia brachiata* (Lour.) Merr. | Rhizophoraceae |
| *Markhamia stipulata* (Wall.) Seem. | Bignoniaceae |
| *Terminalia arjuna* (Roxb.) Wight &Arn. | Combretaceae |
| *Terminalia chebula* Retz. | Combretaceae |
| *Ficus microcarpa* L.f. | Moraceae |
| *Ficus nervosa* B.Heyne ex Roth. | Moraceae |
| *Trema orientale* (Linn.) Blume | Cannabaceae |
| *Saurauia kegeliana* Schltdl. | Actinidiaceae |
| *Oreocnide integrifolia* (Gaud.) Miq. | Urticaceae |
| *Melia azedarach* Linn. | Meliaceae |

ber plants in plantation area was $20.33 \pm 1.21/400M^2$ (Mean $\pm$ SE) whereas in forest area the total individual of tree was $36.09 \pm 2.29/400M^2$ (Mean $\pm$ SE).$1.93 \pm 0.15$ (Mean $\pm$ SE) was Shannon index value, $0.19\pm 0.03$ (Mean $\pm$ SE) was Simpson index value and $0.85 \pm 0.04$ (Mean $\pm$ SE) was evenness value recorded in adjacent forest area.

**Table 3.** Shrub species observed in adjacent forest area and rubber plantation area of Khowai district of Tripura.

| Species | Family | Adjacent forest area | Rubber plantation area |
|---|---|---|---|
| *Clerodendrum viscosum* Vent. | Lamiaceae | √ | √ |
| *Ficus hispida* L.f. | Moraceae | √ | √ |
| *Tabernaemontana divaricata* R.Br. | Apocynaceae | √ | √ |
| *Macaranga peltata* Roxb. | Euphorbiaceae | √ | √ |
| *Chromolaena odorata* Linn. | Asteraceae | √ | √ |
| *Melastoma malabathricum* Linn. | Melastomataceae | √ | √ |
| *Premna esculenta* Roxb. | Lamiaceae | √ | - |
| *Micromelum integerrimum* Roxb. ex DC. | Rutaceae | √ | √ |
| *Bridelia stipularis* (L.) Blume | Phyllanthaceae | √ | - |
| *Hymenodicton excelsum* (Roxb.) Wall. | Rubiaceae | √ | - |
| *Urena lobata* Linn. | Malvaceae | √ | √ |
| *Rauvolfia serpentina* Linn. | Apocynaceae | √ | √ |
| *Phytolacca americana* Linn. | Phytolaccaceae | √ | - |
| *Allophylus serratus* (Roxb.) Kurz. | Sapindaceae | √ | - |
| *Phyllanthus fraternus* G.L.Webster | Phyllanthaceae | - | √ |
| *Lantana camara* Linn. | Verbenaceae | √ | - |
| *Senna occidentalis* Linn. | Fabaceae | - | √ |
| *Mussaenda incana* Wall. | Rubiaceae | - | √ |

**Shrub species present in adjacent forest and rubber plantation area**

In shrub layer of adjacent forest area 15species were recorded. These species was belonging to 15 different genera and 13 families. Maximum species belonged to lamiaceae and apocynaceae family. Shrubby layer in rubber plantation area, 12 species were recorded. This was belonging to 12 different genera 11 different families (Table 3).

**Biodiversity indices of shrubby layer in adjacent forest and rubber plantation area**

In shrub layer mean number of total different species in forest area (4.11 ± 0.45) was higher than that in rubber plantation area (3.56 ± 0.18). It was observed

**Table 4.** Diversity indices and species evenness indices of shrub species in adjacent forest and rubber plantation area.

| Parameters | Adjacent forest area | Rubber area |
|---|---|---|
| Total species (Mean ± SE) | 4.11 ± 0.45 | 3.56 ± 0.18 |
| Total individual (Mean ± SE) | 35.76 ± 6.16 | 18.54 ± 2.04 |
| Shannon index (Mean ± SE) | 1.17 ± 0.11 | 1.08 ± 0.05 |
| Simpson index (Mean ± SE) | 0.40± 0.09 | 0.39 ± 0.03 |
| Species evenness (Mean ± SE) | 0.88 ± 0.01 | 0.89 ± 0.007 |

that the total individuals of shrub plants in rubber plantation area was 18.54 ± 2.04 where as in forest area the total individual of shrub was 35.76 ± 6.16. Maximum value of Shannon index (1.17 ± 0.11) of shrub was recorded in adjacent forest area and minimum Simpson's index value of shrub was observed in rubber plantation area (0.39 ± 0.03). Evenness values more or less similar both the sites (Table 4). Shannon (t=1.672, df=82, p<0.001) and Simpson (t=-1.580, df=82, p<0.001) diversity indices for shrub layer did not show significant differences between rubber plantation area and forest area after t-test.

## Herbaceous plant species present in adjacent forest and rubber plantation

In herb layer of adjacent forest area 40 species were observed. These species belonged to 35genera and 20 families. Maximum number of species belonged to Poaceae and Asteraceae (6, 6 species, respectively) family. In herb layer of rubber plantation area 34 species were recorded which was belonging to 33 genera 20 families (Table 5).

**Table 5.** Herb species observed in forest area and rubber plantation area of Khowai district of Tripura.

| Species | Family | Forest area | Rubber plantation area |
|---|---|---|---|
| *Smilax japonica (*Kunth) A. Grey | Smilacaceae | √ | √ |
| *Curculigo orchioides* Gaertn. | Hypoxidaceae | √ | √ |

**Table 5.** Continued.

| Species | Family | Forest area | Rubber plantation area |
|---|---|---|---|
| *Hemidesmus indicus* (L.) R. Br. | Apocynaceae | √ | √ |
| *Dioscorea sativa* (Hook.f.) Prain | Dioscoreaceae | √ | √ |
| *Alternanthera ficoidea* (L.) . Sm. | Amaranthaceae | √ | - |
| *Cyperus cyperoides* (L.) Kuntze | Cyperaceae | √ | - |
| *Lygodium flexuosum* Linn. | Schizaeaceae | √ | √ |
| *Panicum brevifolium* Linn. | Poaceae | √ | √ |
| *Imperata cylindrica* (L.) P. Beauv. | Poaceae | √ | √ |
| *Vernonia cinerea* (L.) | Asteraceae | √ | √ |
| *Mimosa pudica* Linn. | Fabaceae | √ | √ |
| *Dioscorea pentaphylla* Linn. | Dioscoreaceae | √ | √ |
| *Ampelocissus barbata* (Wall) Planch. | Vitaceae | √ | √ |
| *Pueraria tuberosa* (Willd) DC. | Fabaceae | √ | - |
| *Elephantopus scaber* Linn. | Asteraceae | √ | - |
| *Commelina diffusa* Burm. F. | Commelinaceae | √ | √ |
| *Stephania hernandifolia.* Walp. | Menispermaceae | √ | √ |
| *Cyperus rotundus* Linn. | Cyperaceae | √ | √ |
| *Amorphophallus bulbifer* (Roxb.) Blume | Areceae | - | √ |
| *Spermacoce hispida* Linn. | Rubiaceae | √ | √ |
| *Paspalum conjugatum* P.J.Bergius | Poaceae | √ | √ |
| *Evolvulus nummularius* Linn. | Convolvulaceae | √ | - |
| *Phaulopsis dorsiflora* (Retz.) Santapau | Acanthaceae | √ | √ |
| *Ipomea alba* Linn. | Convolvulaceae | √ | √ |
| *Mucuna bracteata* DC. | Fabaceae | √ | √ |
| *Mikania scandens* BL.Rob | Asteraceae | √ | √ |
| *Cyathula prostata* (L.) Blume. | Amaranthaceae | - | √ |
| *Christella hispidula* (Decne.) | Thelypteridaceae | - | √ |
| *Ageratum conyzoides* Linn. | Asteraceae | √ | √ |
| *Cyperus iria* Linn. | Cyperaceae | - | √ |
| *Scoparia dulcis* Linn. | Plantaginaceae | √ | - |
| *Ottochloa nodosa* (Kunth) Dandy. | Poaceae | √ | √ |
| *Cheilanthes belangeri* (Bory.) C.Chr. | Pteridaceae | - | √ |
| *Kyllinga brevifolia* Rottb. | Cyperaceae | √ | - |
| *Pteris semipinnata* Linn. | Pteridaceae | - | √ |
| *Pueraria phaseoloides* Roxb. | Fabaceae | √ | - |
| *Adiantum philippense* Linn. | Pteridaceae | - | √ |
| *Dendrocalamus hamiltonii* Gamble. | Poaceae | √ | - |
| *Convolvulus arvensis* Linn. | Convolvulacae | √ | - |
| *Costus speciosus* (J.Koenig) Sm. | Zingiberaceae | √ | - |
| *Melocanna baccifera* (Roxb.) Kurz. | Poaceae | √ | - |

**Table 5.** Continued.

| Species | Family | Forest area | Rubber plantation area |
|---|---|---|---|
| *Dioscorea hamiltonii* Hook.F. | Dioscoreaceae | √ | - |
| *Lindernia procumbens* (Krock.) | Linderniaceae - | √ | - |
| *Spermacoce alata* Aubl. | Rubiaceae | √ | - |
| *Blumea laciniata* (Roxb.) DC. | Asteraceae | √ | - |
| *Cyathea dealbata* (G.Forst.) C prest. | Cyatheaceae | √ | - |
| *Dichrocephala integrifolia* (L.F.) kuntze | Asteraceae | √ | - |
| *Centella asiatica* (L.) Urban | Apiaceae | - | √ |
| *Blumea lacera* (Burm.f.) DC. | Asteraceae | - | √ |
| *Amaranthus gracilis* Desf. | Amaranthaceae | - | √ |
| *Alternanthera philoxeroides* (Mart.) Griseb. | Amaranthaceae | - | √ |
| *Oplismenus compositus* Linn. | Poaceae | - | √ |

## Biodiversity indices of herb layer in adjacent forest and rubber plantation area

In herb layer the mean number total different species in forest area (4.72 ± 0.45) was higher than that in rubber plantation area (3.72 ± 0.31). It was observed that the total individuals of herb in rubber plantation area was 50.06 ± 2.63/1M$^2$ where as in forest area the total individual of herb was 68.09 ± 10.23/1M$^2$. Maximum value of Shannon index (1.15 ± 0.14) of herb was recorded in adjacent forest area and maximum Simpson's index value of herb was observed in rubber plantation area (0.55 ± 0.03). Statistically, more evenness value (0.78 ± 0.03) observed in adjacent forest area and minimum (0.67 ± 0.01) in rubber plantation area (Table 6). Shannon (t=7.850, df=124,

**Table 6.** Diversity indices and species evenness indices of herb species in forest and rubber plantation area.

| Parameters | Adjacent forest area | Rubber area |
|---|---|---|
| Total species (Mean ± SE) | 4.72 ± 0.45 | 3.72 ± 0.31 |
| Total individual (Mean ± SE) | 68.09 ± 10.23 | 50.06 ± 2.63 |
| Shannon index (Mean ± SE) | 1.15 ± 0.14 | 0.85± 0.07 |
| Simpson index (Mean ± SE) | 0.35 ± 0.02 | 0.55 ± 0.03 |
| Species evenness (Mean ± SE) | 0.78 ± 0.03 | 0.67 ± 0.01 |

p<0.001) and Simpson (t=-8.498m df=124; p<0.001) diversity indices for herb layer show significant differences between rubber plantation area and forest area after t-test.

## DISCUSSION

The present study indicates that an excessive rubber plantation has adverse effects on non human-primates and other plant kingdom. Due to deforestation and increasing monoculture plantations in Indonesia's Sumatra region, *Presbytis melalophos* and *colobines* move to rubber plantations in search of food for their survival (Danielsen and Heegard 1995). Oil palm and rubber plantations play a major role in the decrease of faunal diversity especially in primary forest (Fitzherbert *et al.* 2008). Human activities have an eroding effect on the abundance and conservation of old world monkey groups in Tripura (Patari and Dasgupta 2022). In the present study most of the tree species in forest area near the rubber plantation area belonged to the family Moraceae. Majumder and his coworker (2012) reported that Moraceae was major predominant in lowland moist deciduous to moist mixed deciduous forest of Tripura. 400 M$^2$ plot in adjacent forest area mean number of different tree species was 36.09 ± 2.29 (Mean ± SEM), whereas since rubber is a monoculture plantation it directly implies that rubber plantation has impacts on composition of species (Truong and Bao 2017). Recorded Shannon, Simpson index value and evenness value of tree species in adjacent forest area were indicative that moderate species diversity, high degree of species richness and equal proportion of all species distribution in the study areas (Vyas and Joshi 2013). Mean number of different shrub and herb species in nearest forest area much higher than the rubber plantation area which indicated that rubber plantation has impact on species composition of understory plants (Truong and Bao 2017). Maximum value of Shannon index of shrub and herb was observed in adjacent forest area, which revealed that forest area had more shrub and herb species diversity (Vyas and Joshi 2013). Maximum Simpson's dominance index value of shrub observed in forest area and in herb layer maximum Simpson's dominance index value observed in rubber plantation area. High Simpson's dominance index values indicate lower species richness value (Vyas

and Joshi 2013). Species evenness values more or less similar for all the sites and there is no significant variation among themselves. Most study reported that forest biodiversity index was higher in all vegetation layers as compared to monoculture plantation (Pourbabaei *et al.* 2012, Taleshi 2013, Sobuj and Rahman, 2011). Now a day due to increasing human activity in rubber plantation areas, the numbers of understory plant species become less. Though shrub and herb species were observed in the plantation area but various tree species were generally not abundant. It is likely that the mammals don't find preferred food materials in rubber plantation. As a result they enter into the agricultural land and urban areas, which causes conflict between human and non-human primate. This consciences result is detrimental effect on local people and their properties, or non-human primates and their habitat in Sepahijala district of Tripura (Patari and Dasgupta 2022).

## CONCLUSION

This research work first time identified the tree, shrub and herbaceous plants community present in Khowai district of Tripura and also described the biodiversity indices. This baseline information helps in management of forest area in this district. Excessive human activities and increasing rubber plantation lead to treats of several living organisms. Maximum number of economically weak people of this district become financially stable due to quickly expanding rubber plantation in this area, however all the government agencies, forest department and general people, conservation ecology students must take initiative to protect the unique natural resources and wildlife of this state. Implementing a eco-friendly rubber plantation in a proper way while maintaining balance of biotic and abiotic ecosystem so that wildlife can stay without fear and human economic development take place.

## ACKNOWLEDGMENT

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