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Phyto-regeneration and diversity indices of West Rajabhatkhawa Range of Buxa Tiger Reserve of West Bengal, India

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ABSTRACT

The present study was carried out to investigate tree species diversity, population dynamics, and tree species regeneration patterns at Rajabhatkhawa Range of Buxa Tiger Reserve of West Bengal to better understand the regeneration dynamics and population structure of tree species. A total of 140 quadrats (size 2m × 2 m) were set with the sampling intensity 0.1% for regeneration survey of the area by following random quadrat sampling method. This study documented about ″106" regenerating tree species, representing "74" genera and "40" families from the study area from which about "47" percent of tree species showed "good" regeneration status. *Monoon simiarum* had highest seedlings density with 8125.00 seedlings ha^{-1} followed by *Aglaia spectabilis* (4642.86 seedlings ha^{-1}). *Monoon simiarum* showed highest IVI index of 15.19, followed by *Aglaia spectabilis* (10.41). About 9 percent of the species had "fair" regeneration status and 8 percent had "poor" regeneration status, the fair or poor regeneration might be due to insufficient seed dispersal that limits native species colonisation. However, it was observed that a total of 18 percent of tree species were classified as "not regenerating" and again 18 percent of tree species that were present in either sapling or seedling stage but no adult stage were categorized as new regeneration.

Key words : *West Rajabhatkhawa, Regeneration, Diversity, Quantitative, Buxa Tiger Reserve (B.T.R)*

Introduction

Despite the importance of the forest ecosystems, a significant proportion have been degraded and lost in most parts of the world, including India, which is the one of the twelfth megadiverse countries of the world. The loss and degradation of forest ecosystems can be attributed to various demographic and socio-economic pressures, modernization along with institutional and policy failures. The world-wide ecological community is deeply concerned about biodiversity loss, particularly in developing nations. Species composition and regeneration indicate the health of the forest. Understanding the growth status of a species in the ecosystem is critical and it is one of the primary parameters used to de-

termine ecological stability (Kadavul and Parthasarathy, 2001; Deb and Sundriyal, 2011). It outlines how organisms spread and respond to environmental changes. Plant diversity in any location is influenced by species distribution and abundance trends (Palit *et al.*, 2012) responsible for change in ecological features of forest community which mostly depends upon species diversity and regeneration status (Khumbongmayum *et al.*, 2006). Natural regeneration makes use of the parent stand's reproductive ability to give rise to a new forest generation, which might arise from dispersed seeds, coppice shoots or root suckers. To understand the tree population dynamics, regeneration patterns and diversity assessment is required of the forest composition and structure (Mishra *et al.*, 2013; Singh *et al.*, 2016; Dash *et al.*, 2021). Regeneration studies can show the current state of forest composition and give projections about future forest composition (Henle *et al.*, 2004). It may be anticipated by looking at the number of seedlings, saplings and adult trees in a given forest (Austin, 1977). Forest crop regeneration is a necessary condition for the practise of scientific forestry, as failure or under performance on this point will jeopardise the sustainability of forest yield. The natural regeneration is mostly influenced by the production of sufficient amounts of fertile seeds by the trees in the area or immediate vicinity which is governed by the species, age of tree, soil conditions, climate, crown and other external factors. The presence of a sufficient number of young trees, saplings and seedlings in a certain forest population signifies the capable of successful regeneration of tree species (Khan *et al.*, 1987). However, most of the forests are under immense anthropogenic disturbances and require careful management intervention to maintain overall biodiversity and sustainability.

Therefore, it is essential to conduct the survey for quantitative analysis of different types of vegetation along with structure and composition to study the overall spectrum of vegetation along with regeneration status of the area. West Rajabhatkhawa Range has a multi-tier vegetation assemblage, it can be broadly classified as East Himalayan sub-tropical wet hill forest of Champion and Seth's classification ($8B/C_1$). The total area of the reserve is 760.87 km^2 of which 390.58 km^2 has been constituted as Wildlife Sanctuary and National Park and the rest 370.29 km^2 areas is Reserve Forest and other Protected Areas. The total core area of Buxa Tiger Reserve is of 417.5 km^2. A distinct variation of plant composition is visible as the range extends from plains up to an elevation of 1800 meter in the hills depending upon altitude, soil, topography, etc. That's why, the present study was carried out to determine tree species diversity, population dynamics and tree species regeneration patterns at West Rajabhatkhawa Range of Buxa Tiger Reserve.

Materials and Methods

The study was conducted in West Rajabhatkhawa Range of Buxa Tiger Reserve, West Bengal, India during 2019-2022. Previously, Buxa Tiger Reserve was constituted in the year 1983 as the 15th Tiger Reserve of the country. It is located in Alipurduar District of West Bengal. The Reserve lies between 26°30′ and 26°55′N latitudes and 89°20′ and 89°55′E longitudes. The area was spread over 50 km from West to East and 35 km from North to South direction. The average daily temperature of the region varied from 12 °C to 32 °C and the mean annual precipitation of 4100 mm dominated by South-West monsoon.

The West Rajabhatkhawa Range (Figure 1) spreads over 6790.82 hectare out of which 5631 hectare was under forest area cover, 367.15 hactare

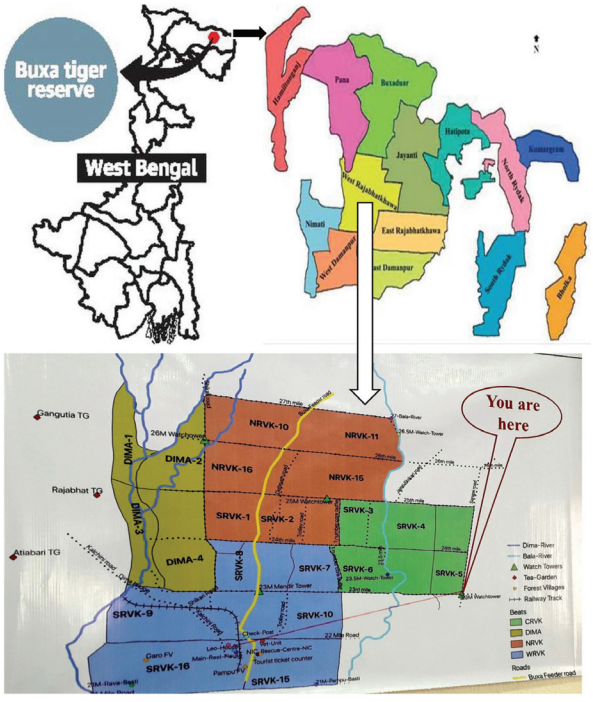

Fig. 1. Location of West Rajabhatkhawa Range the study area

had village cover and 792.67 hectare was under riverbed, road and railway tracks. With the sampling intensity of 0.1%, a total 140 quadrates of 2 m x 2 m size were laid out with designated coordinates for regeneration survey and phytosociological study of the area by following random quadrat sampling method.

All the species and individuals encountered in each quadrat was counted and the girth of individuals having ≤ 30 cm girth (gbh) was considered as adult, saplings with ≤ 10 cm to < 30 cm girth and seedlings with < 10 cm girth and then status of regeneration of species was determined based on population size of seedlings, saplings and adults as (outlined by Khan *et al*., 1987; Shankar, 2001; Khumbongmayum *et al.,* 2006). The regeneration levels of species was assessed using population size of seedlings, saplings, and adults as follows: (a) "good," if seedlings > or saplings > adults; (b) "fair," if seedlings > or saplings adults; (c) "poor," if a species survives only in sapling stage, but no seedlings (though saplings may be > or = adults); (d) "none," if it is absent both in sapling and seedlings stages, but found only in adults; and (e) "new," if any new species was recorded. Quantitative community metrics such as frequency, density, abundance, relative frequency, relative density, relative dominance and Importance Value Index was also determined by following the standard protocols as per Bray and Curtis (1957) and Mishra *et al.* (2005). Apart from this, diversity index (Shannon and Weaver, 1963), concentration of dominance (Simpson, 1949), species richness (Margalef, 1968) and evenness index (Pielou, 1966) were also calculated. Plants were identified with the help of the local people, forest guards and taxonomist as well. Apart from this various field guide books viz. Flora of North Bengal, Forest Resources of North Bengal, Buxa Tiger Conservation Plan 2015-2024, online resources viz. www. worldfloraonline.org and powo.science.kew.org was also consulted and referred for the present study.

Results and Discussion

Regeneration potential

The study revealed that a total of 106 number of regenerating species were recorded from a total number of 140 quadrates from the sampled area. The identified communities had been classified based on their regeneration status, i.e., the proportion of saplings and seedlings in the population. So, in this study, 47 percent of tree species showed "good" regeneration status, 9 percent had "fair" regeneration status, and 8 percent had "poor" regeneration status, which might be due to the soil quality, the presence of weedy growth of invasive plant species that hinders the natural regeneration process, or sometimes seed year, insufficient seed dispersal that limits native species colonisation that are responsible for the environmental variables that might impact natural regeneration Benayas *et al.* (2008). It was observed that, a total of 18 percent of tree species were classified "not regenerating" as per the above reasons while, 18 percent of tree species that were present in either sapling or seedling stage were categorized under "new regenerating species" in BTR Rajabhatkhawa Range (Figure 2). Canopy density regulates the interspace and allow penetration of light to the forest floor that favours the seedling early growth (Webb and Sah, 2003). The presence of saplings and seedlings indicated the future trends of regeneration status of any forest through regeneration (Dhar *et al.*, 1997; Samant *et al.*, 2002; Singh and Singh, 1992). Species regeneration is influenced by numerious factors viz. light, canopy density, soil moisture regime, fertility and anthropogenic disturbance (Iqbal *et al.*, 2012).

Fig. 2. Regeneration status of West Rajabhatkhawa Range of B.T.R

Seedlings density

A total of 106 species, representing 74 genera and 40 families were found. Fabaceae, Meliaceae and Lauraceae had the most number of species (8 each), followed by Lamiaceae (7), Phyllanthaceae (5), Combretaceae (4), Apocynaceae, Euphorbiaceae, Fagaceae, Lythraceae, Magnoliaceae, Malvaceae, Myrtaceae and Rutaceae (3 each), Anacardiaceae,

Bignoniaceae, Dilleniaceae, Dipterocarpaceae, Elaeocarpaceae, Moraceae and Rubiaceae (2 each), while the remaining 18 families had one species each. Fabaceae, Lauraceae and Meliaceae contributed 8.25% of the stand density, followed by Lamiaceae (7.22%), Phyllanthaceae (5.15%) and Combretaceae (4.12%). If the seedling density is higher than sapling and adult densities, it indicates overall strong regeneration status hence in this regeneration study it was found that *Monoon simiarum* (8125.00 seedlings ha^{-1}) had the highest number of regenerating seedlings, followed by *Aglaia spectabilis* (4642.86 seedlings ha^{-1}), *Syzygium nervosum* (4375.00 seedlings ha^{-1}), and *Knema erratica* (4357.14 seedlings ha^{-1}). Species like *Viburnum erubescence* (26.96 seedlings ha^{-1}), *Bauhinia variegata* (20.36 seedlings ha^{-1}), *Styrax serrulatum* (16.43 seedlings ha^{-1}), *Castanopsis indica* (13.04 seedlings ha^{-1}) and *Murraya koenigii* (9.64 seedlings ha^{-1}) had lesser seedling density. There was some species that showed no regeneration viz. *Semecarpus anacardium*, *Machilus glaucescens*, *Ehretia laevis*, *Ficus racemosa*, *Bridelia retusa*, *Syzygium cumini*, *Euryaa cuminata*, *Machilus glaucescens*, *Morus indica*, *Dysoxylum gotadhora*, *Cinnamomum glaucescens* and *Beilschmiedia roxburghiana* etc. Higher seedling density was recorded in the present study was due to higher rainfall, soil fertility and other agro-climatic factors. The appearance of new species at under storey might be due to long range movement of fauna that accelerated ecesis process. Similar result was recorded by Singh *et al.* (2016) in Garhwal Himalayas (9,600-1,550 individual ha^{-1}) and Pant and Sammant (2012) in North-western Himalaya (145 -1,290 individual ha^{-1}).

Population structure

Important Value Index of a species indicates or determines how dominating it is in a certain forest region, it is typically an inventory tool. As per the data illustrated in Table 1, the highest IVI was recorded in *Monoon simiarum* (15.19), followed by *Aglaia spectabilis* (10.41), *Knema erratica* (9.63), *Syzygium nervosum* (8.99) and *Actinodaphne obovata* (8.94). These five species had highest values in that area. The least IVI value was recorded in *Castanopsis tribuloides* (2.16), *Shorea robusta* (2.16), *Terminalia citrina* (1.97), *Litsea cubeba* (1.69) and *Terminalia chebula* (1.67). In similar study, Pramanik and Das (2015) also recorded the highest IVI in *Aglaia spectabilis* (52.5 and 45.0) at Buxa Tiger Reserve (BTR) and Gorumara National Park, respectively, which supports the present investigation. In another study Sarkar and Das (2017) recorded that *Shorea robusta* had the highest IVI with 28.08, followed by *Aglaia spectabilis* (14.98) and least in *Tectona grandis* (5.88) and *Schima wallichii* (6.73) at Jainti forest of Buxa Tiger Reserve.

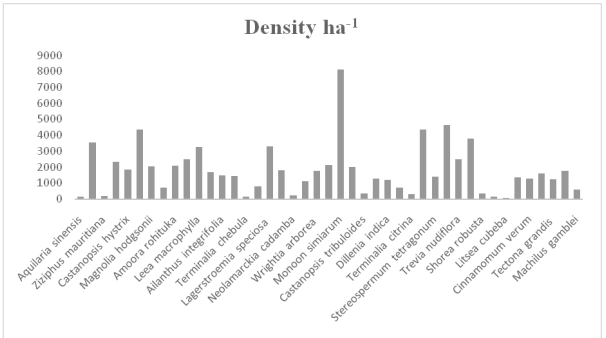

Fig. 3. Density structure of West Rajabhatkhawa Range of B.T.R

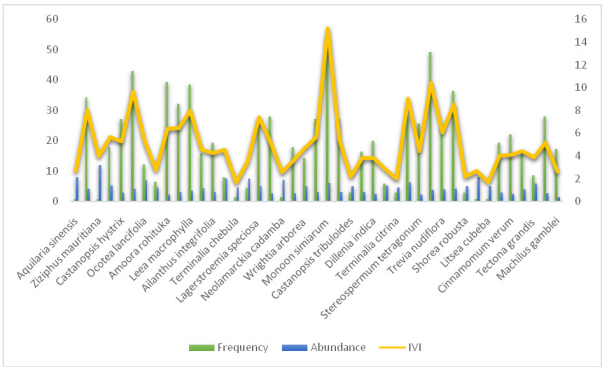

Fig. 4. Frequency, abundance and IVI of different species present in West Rajabhatkhawa Range of B.T.R

Species diversity

In general, the West Rajabhatkhawa Region is equally diverse and rich in species distribution, the forest stratification was dense and had multi type structure. For the regenerating species, the Diversity Index, Concentration of dominance, species richness and Evenness index were estimated as 5.55, 0.02, 9.16 and 1.19 respectively indicating high density in forest community (Figure 5). Species diversity is a two-part statistical concept. These two elements are number of species and Equitability or Evenness. Ecological dominating species are those that have the most control over energy flow and the environment in a specific area (Simpson, 1949). Behera *et al.*(2021) also observed the diversity index, Species richness and evenness index which were 4.81, 7.97 and 1.28 respectively in Kuldiha Wildlife Santuary,

Table 1. Density, frequency, abundance and IVI of the top tree species

Name of the Species	Density ha^{-1}	Frequency	Abundance	IVI
Aquilaria sinensis	142.86	0.71	8.00	2.66
Viburnum erubescence	3535.71	34.29	4.13	8.02
Ziziphus mauritiana	214.29	0.71	12.00	3.96
Tabernaemontana divaricate	2321.43	17.86	5.20	5.62
Castanopsis hystrix	1875.00	27.14	2.76	5.23
Knema erratica	4357.14	42.86	4.07	9.63
Magnolia hodgsonii	2071.43	12.14	6.82	5.34
Murraya koenigii	732.14	6.43	4.56	2.73
Amoora rohituka	2107.14	39.29	2.15	6.36
Meyna spinosa	2482.14	32.14	3.09	6.41
Leea macrophylla	3285.71	38.57	3.41	7.92
Mimosa extensa	1714.29	15.71	4.36	4.53
Ailanthus integrifolia	1500.00	19.29	3.11	4.24
Morinda citrifolia	1464.29	7.86	7.45	4.52
Terminalia chebula	160.71	1.43	4.50	1.67
Pterospermum acerifolium	803.57	4.29	7.50	3.52
Lagerstroemia speciosa	3321.43	27.14	4.89	7.40
Syzygium cumini	1821.43	27.86	2.62	5.19
Neolamarckia cadamba	250.00	1.43	7.00	2.53
Sarcosperma arboreum	1142.86	17.86	2.56	3.57
Wrightia arborea	1785.71	14.29	5.00	4.67
Baccaurea ramiflora	2142.86	27.14	3.16	5.63
Monoon simiarum	8125.00	54.29	5.99	15.19
Aphanamixis polystachya	2017.86	27.14	2.97	5.44
Castanopsis tribuloides	357.14	2.86	5.00	2.16
Sterculia foetida	1285.71	16.43	3.13	3.77
Dillenia indica	1214.29	20.00	2.43	3.80
Vitex quinata	732.14	5.71	5.13	2.84
Terminalia citrina	321.43	2.86	4.50	1.97
Syzygium nervosum	4375.00	27.86	6.28	8.99
Stereospermum tetragonum	1392.86	25.71	2.17	4.41
Aglaia spectabilis	4642.86	49.29	3.77	10.41
Trevia nudiflora	2482.14	25.00	3.97	6.04
Actinodaphne obovata	3785.71	36.43	4.16	8.49
Shorea robusta	357.14	2.86	5.00	2.16
Magnolia oblonga	142.86	0.71	8.00	2.66
Litsea cubeba	89.29	0.71	5.00	1.69
Mallotus pallidus	1357.14	19.29	2.81	4.00
Cinnamomum verum	1303.57	22.14	2.35	4.06
Bauhinia purpurea	1625.00	16.43	3.96	4.38
Tectona grandis	1232.14	8.57	5.75	3.82
Turpinia pomifera	1785.71	27.86	2.56	5.14
Machilus gamblei	607.14	17.14	1.42	2.60
Others	16821.43	298.57	132.11	84.64
Total	95285.71	1124.29	326.79	300.00

Odisha. Similarly, Saikia (2016) also recorded that the diversity index, Species richness and evenness index were 3.99, 18.31 and 0.79 correspondingly. For Indian forests the Shannon diversity Index ranges from 0.83 to 4.1 accordingly (Devi and Yadava, 2006). Both the plot's heterogeneity and the number of individuals have an impact on the observed species diversity. Therefore we can observe in this case that the Diversity Index is higher in this region because of the resultant set which can be anticipated to be larger if individuals are selected from several environments as compared to a single. Larger re-

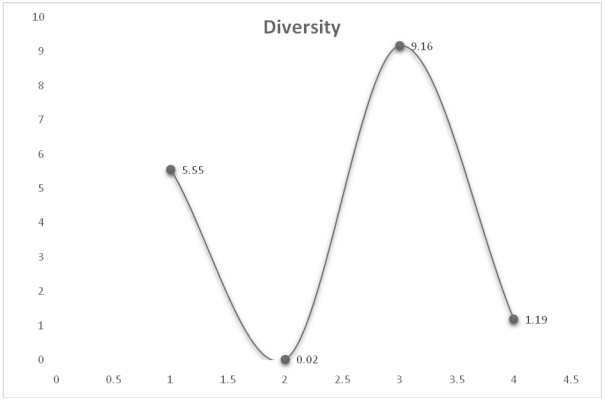

Fig. 5. Diversity Index, concentration of dominance, species richnessand evenness indexof West Rajabhatkhawa Range of B.T.R

gions have greater species diversity than smaller ones, increasing the sampled area results in an increase in the observed species diversity.

Conclusion

Seedlings contributed the most to the total population, followed by saplings and mature trees, according to the general population structure of tree species in the research area. *Monoon simiarum* showed the highest seedlings density followed by *Aglaia spectabilis* and the major tree species was also *Monoon simiarum* with IVI index of 15.19, again followed by *Aglaia spectabilis* which was 10.41. The present study gives quantitative data of tree species diversity, population structure, and regeneration status which may give benchmark information for conservation and management plans for the forest range.

Acknowledgement

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