Indian Journal of Ecology (2024) 51(2): 309-315
DOI: https://doi.org/10.55362/IJE/2024/4235

Manuscript Number: 4235
NAAS Rating: 5.38

Effect of Altitudinal Gradation on Regeneration Status of NTFP Species in Central Western Ghats of Karnataka

Raviraj, S.S. Inamati, B.H. Ganesha*, M.R. Jagadish and Rajath Kumar

College of Forestry, Sirsi, University of Agricultural Sciences, Dharwad-581 401, India
**E-mail: ganeshforicofcp@gmail.com*

Abstract: The regeneration is the important criteria for the growth and survivability of forests and he current study was conducted to observed the regeneration status of NTFP species along altitudinal gradation in central Western ghats. Quadrate sample plot method was adopted for collection of data. the regeneration diversity of *Psychotria flavida* with an Important Value Index (IVI) value 22.8, *Knema attenuate* 23.52 and *Murraya paniculata* 8.81 was dominated in coastal, midghat and plane zone respectively, followed by *Hopea ponga* in Coastal and midghat zone and *Caryota urens* in Plane zone. In Family Importance Value (FIV) of Rubiaceae (33.60) recorded highest in coastal, Myristicaceae (19.50) in midghat zone and Rutaceae (16.57) in plane zone. Among the size class distribution for all the species in different altitudinal ranges, the decreasing trend of stems of lower size to higher size class exhibiting a reverse J-shape curve graph indicating promising growth of regenerating species.

Keywords: Regeneration, NTFP, Altitudinal gradation, Central Western Ghats, Size class distribution

The forests are characterized by high species richness, biomass and productivity. The nature of forest communities depends on the ecological characteristics in sites, species diversity and regeneration of species (Rahman et al 2011). There are millions of people living in and around the forests subsists on collections of non-timber forest products (NTFPs). Their livelihood is dependent on these forest resources (Prasad and Nageeb 2012). Successful regeneration of a species depends on the ability of seedlings and saplings to survive, grow and ability to initiate new seedlings. It is important step for achieving the long-term sustainability of forests (Saikia and Khan 2013). A successful regeneration perhaps indicated by sufficient number of seedlings, saplings and young trees in a given population (Pokhriyal et al 2010) and number of seedlings of any species can be considered as the regeneration potential of that species (Negi and Nautiyal 2005). The potential regenerative status of tree species depicts the composition of forests within a stand in space and time (Henle et al 2004). Natural regeneration is a central component for forest ecosystem dynamics (Getachew et al 2010) and is essential for preservation and maintenance of biodiversity (Rahman et al 2011). It is important to know the growth and development` status of species in the ecosystem and is a key parameter to determine ecosystem stability (Kadavul and Parthasarathy 2001; Deb and Sundriyal 2011). Plant regeneration studies are essential for advancing our knowledge of ecological processes, promoting sustainable practices in Western Ghat belt and addressing global challenges such as biodiversity loss, conservation issues of endangered species and climate change.

MATERIAL AND METHODS

The experiment was conducted in the Central Western Ghats of Uttara Kannada, two taluks of Uttara Kannada district namely Honnavara, Siddapura and Soraba in Shivamogga district. The study site falls under the administrative jurisdiction of Canara Forest Circle, represented by Siddapur Forest Range in the Sirsi territorial i.e. 14°23' N to 14°23'38"N and 74°48'E to 74'38"E. Forest Division, Kumta and Gersoppa forest ranges in the Honnavara territorial Forest Division. Shivamogga Forest Circle, represented by Soraba Forest Range in the Sagar territorial Forest Division. The altitude varies from 0 to 750 m above sea level. The entire area was demarcated with the help of toposheet. The study area was divided into three vegetation strata that occurred between 0-250 m, 251-500 m, and 501-750 m. Survey was undertaken and vegetation in relation to altitudinal gradient was demarcated. Quadrate sample plot method was adopted for analysing vegetation composition of all types. Total of 60 sample plots were laid out to gather information on the regeneration of species. To assess the status of regeneration of species, within the 20 m × 20 m quadrates, two sub plots of size 5 × 5 m quadrates were laid out in two corners of the quadrate. Within the quadrates all the regenerating individuals were identified and

counted. For ease of counting, regenerating individuals were classified into following four classes based on their height and girth.

Class - I, = All individuals below 40 cm height

Class - II = All individuals between 40-100 cm height

Class - III = All individuals between and >100 cm height and <5 cm gbh

Class - IV = All the individuals between 5-10 cm gbh

Herbarium specimens were collected for species identification and the data were subjected to computation and analysis for results to know regeneration status across altitudinal gradient.

RESULTS AND DISCUSSION

Regeneration status of NTFP species: Coastal zone consists of 3277 individuals representing 91 species (Table 1). The number of individuals were maximum for *Psychotria flavida* (570 individuals ha^{-1}) followed by *Hopea ponga* ($^{-1}$) and *Knema attenuata* ha^{-1}) against a total number of individuals (3277 individuals ha^{-1}). Extent of frequency of seedlings of various species in coastal zone ranged between 2.5 to 52.5 per cent, *Hopea ponga* was most frequent species (52.5 %) followed by *Knema attenuata* (47.5 %) and *Psychotria flavida* (45 %). The importance value index of regenerates of seedlings for *Psychotria flavida* was (22.08) followed by *Hopea ponga* and *Knema attenuata.* Rawat et al (2018) also reported the higher seedling regeneration of *Evodia fraxinifolia, Lindera nacusua*, *Machilus duthiei*, *Viburnum nervosum* in the site lying in the lower altitudinal zone. The midghat zone consists of 2647 individuals representing 89 species (Table 2). The number of individuals was highest for *Knema attenuata* (419 individuals ha^{-1}) followed by *Hopea ponga* (ha^{-1}) and *Aglaia elaeagnoidea* ($^{-1}$) as against a total number of individuals (2647 individuals ha^{-1}). The frequency of seedlings of various species in ghat zone ranged between 2.5 to 87.5 per cent, *Knema attenuata* (87.5 %) was most frequent and abundant species followed by *Hopea ponga* (%). Importance value index of regenerates was a maximum for *Knema attenuata* (23.52) followed by *Hopea ponga*, *Aglaia elaeagnoidea* and *Garcinia gummigutta*. Higher values of percent frequency distribution associated with these species may be due to a greater number of matured trees in the midghat zone, which in turn might have resulted in higher amount of seed supply and consequently to better regeneration. Malik and Bhatt (2016) reported majority (27 - 56 %) of species showed good regeneration, a good percentage

Table 1. Regeneration diversity of NTFP species at coastal zone (0-250 m)

Rank	Species	No. of individual/ha	Rel. density	Frequency	Rel. frequency	IVI
1	*Psychotria flavida*	570	17.39	45	4.69	22.08
2	*Hopea ponga*	374	11.41	52.5	5.47	16.88
3	*Knema attenuate*	287	8.76	47.5	4.95	13.71
4	*Aporosa lindliyana*	231	7.05	42.5	4.43	11.48
5	*Uvaria narum*	187	5.71	35	3.65	9.35
6	*Ixora brachiata*	153	4.67	42.5	4.43	9.1
7	*Diospyros buxifolia*	132	4.03	30	3.13	7.15
8	*Calamus thwaitessi*	101	3.08	27.5	2.86	5.95
9	*Caryota urens*	79	2.41	30	3.13	5.54
10	*Memecylon umbellatum*	94	2.87	22.5	2.34	5.21
82	*Hydnocarpus pentendra*	1	0.03	2.5	0.26	0.29
83	*Madhuca longifolia*	1	0.03	2.5	0.26	0.29
84	*Persea macrantha*	1	0.03	2.5	0.26	0.29
85	*Stereospermum personatum*	1	0.03	2.5	0.26	0.29
86	*Strychnus wallichiana*	1	0.03	2.5	0.26	0.29
87	*Symplocos racemosus*	1	0.03	2.5	0.26	0.29
88	*Syzygium hemisphericun*	1	0.03	2.5	0.26	0.29
89	*Vateria indica*	1	0.03	2.5	0.26	0.29
90	*Zanthoxylum flavscens*	1	0.03	2.5	0.26	0.29
91	*Z. rhetsa*	1	0.03	2.5	0.26	0.29
	Total	3277	100	960	100	200

(19 - 45 %) registered poor regeneration while fair regeneration of by 7 - 30 per cent of species and new regeneration by 0 - 14 per cent. Plane zone consists of 2989 individuals representing 136 species (Table 3). The number of individuals was found to be highest for *Murraya paniculata* (197 individuals ha^{-1}) followed by *Caryota urens* (122 individuals ha^{-1}), *Aporosa lindliyana* and *Syzygium cumini* (102 individuals ha^{-1} each) as against a total number of individuals (2989 individuals ha^{-1}). The frequency of seedlings of various species in Plane zone ranged between 2.5 to 50 per cent *Caryota urens* is found to be most frequent species (50 %) followed by *Ixora brachiata* (40 %). In terms of the importance value index of regenerates of seedlings recorded for *Murraya paniculata* found to be highest (8.81) followed by *Caryota urens* and *Ixora brachiata* . The extent of regeneration was found to be inversely proportional to the altitude in the study area although exceptions were found to be associated with some sites with good microclimate condition. The increase in seedling density in the lower (0-250 m MSL) altitudinal zone may be due to land sliding effect which might have eroded with the soils of higher altitudinal zone and depositing it on the lower altitudinal zone. This might have increased the productive capacity of Coastal zone, which in turn might have supported the better seedling regeneration.

Regeneration status of NTFP families: Coastal zone exhibited a total of 39 families with 91 species (Table 4). Of the total number of individuals (3277 individuals ha^{-1}), the Rubiaceae recorded highest number of individuals (849) followed by Dipterocarpaceae and Myristicaceae . Rubiaceae family recorded highest number of species (7) followed by Lauraceae , Arecaceae and Rutaceae . The analysis of overall share of various families assessed in terms of family importance value, Rubiaceae family was most dominant (33.60) followed by Dipterocarpaceae and Arecaceae . The midghat zone exhibited a total of 41 families with 89 species. Of the total number of individuals (2647 individuals ha^{-1}) (Table 5). Myristicaceae recorded highest number of individuals (427) followed by Dipterocarpaceae (341) and Rubiaceae (289). Myrtaceae and Rutaceae were recorded highest number of species (7 species each) followed by Rubiaceae, Arecaceae and Lauraceae , Dipterocarpaceae and Annonaceae. In terms of the family importance value, Myristicaceae family found to be most dominant (19.50) followed by Rubiaceae (17.66) and Dipterocarpaceae (17.38). The plane zone consisted of 47 taxonomic groups. Of the total number of individuals (2989 individuals ha^{-1}) (Table 6). Rutaceae recorded highest number of individuals (277) followed by Rubiaceae and

Table 2. Regeneration diversity of NTFP species at midghat zone (251-500 m)

Rank	Species	No of individual/ha	Relative density	Frequency	Relative frequency	IVI
1	*Knema attenuate*	419	15.83	87.5	7.69	23.52
2	*Hopea ponga*	281	10.62	62.5	5.49	16.11
3	*Aglaia elaeagnoidea*	177	6.69	60	5.27	11.96
4	*Garcinia gummigutta*	155	5.86	65	5.71	11.57
5	*Ixora nigricans*	118	4.46	50	4.40	8.85
6	*Psychotria flavida*	120	4.53	22.5	1.98	6.51
7	*Garcinia Morella*	85	3.21	35	3.08	6.29
8	*Caryota urens*	66	2.49	40	3.52	6.01
9	*Neolitsea zelanica*	53	2	35	3.08	5.08
10	*Syzygium gardneri*	115	4.34	5	0.44	4.78
70	*Capparis heyneana*	1	0.04	2.5	0.22	0.26
81	*Cinnamomum macrocapum*	1	0.04	2.5	0.22	0.26
82	*Clausena indica*	1	0.04	2.5	0.22	0.26
83	*Elaeagnus conferta*	1	0.04	2.5	0.22	0.26
84	*Grewia umbellifera*	1	0.04	2.5	0.22	0.26
85	*Luvunga sarmentosa*	1	0.04	2.5	0.22	0.26
86	*Pinanga dicksonii*	1	0.04	2.5	0.22	0.26
87	*Syzygium cumini*	1	0.04	2.5	0.22	0.26
88	*S. jambos*	1	0.04	2.5	0.22	0.26
89	*Thottea siliquosa*	1	0.04	2.5	0.22	0.26
	Total	2647	100	1137.5	100	200

Table 3. Regeneration diversity of NTFP species at plane zone (501-750 m)

Rank.	Species	No of individual/ha	Relative density	Frequency	Rel frequency	IVI
1	*Murraya paniculata*	197	6.59	30	2.22	8.81
2	*Caryota urens*	122	4.08	50	3.7	7.79
3	*Ixora brachiata*	96	3.21	40	2.96	6.17
4	*Aporosa lindliyana*	102	3.41	35	2.59	6.01
5	*Garcinia gummigutta*	85	2.84	37.5	2.78	5.62
6	*Knema attenuate*	86	2.88	32.5	2.41	5.28
7	*Aglaia elaeagnoidea*	76	2.54	35	2.59	5.14
8	*Calycopteris floribunda*	101	3.38	22.5	1.67	5.05
9	*Syzygium cumini*	102	3.41	20	1.48	4.89
10	*Leea indica*	83	2.78	27.5	2.04	4.81
127	*Ficus hispida*	1	0.03	2.5	0.19	0.22
128	*Garcinia talboti*	1	0.03	2.5	0.19	0.22
129	*Gmelina arborea*	1	0.03	2.5	0.19	0.22
130	*Jasminum malabaricum*	1	0.03	2.5	0.19	0.22
131	*Madhuca latifolia*	1	0.03	2.5	0.19	0.22
132	*Mappia foetida*	1	0.03	2.5	0.19	0.22
133	*Memecylon terminale*	1	0.03	2.5	0.19	0.22
134	*Murraya exotica*	1	0.03	2.5	0.19	0.22
135	*Ochlandra species*	1	0.03	2.5	0.19	0.22
136	*Syzygium hemisphericun*	1	0.03	2.5	0.19	0.22
	Total	2989	100	1350	100	200

Table 4. Regenerating families of NTFP species at coastal zone (0-250 m)

Rank	Family	No. of individual/ha	No. of species	Relative density	Relative diversity	FIV
1	Rubiaceae	849	7	25.91	7.69	33.6
2	Dipterocarpaceae	375	2	11.44	2.2	13.64
3	Arecaceae	233	5	7.11	5.49	12.6
4	Euphorbiaceae	285	3	8.7	3.3	11.99
5	Annonaceae	283	3	8.64	3.3	11.93
6	Myristicaceae	292	2	8.91	2.2	11.11
7	Lauraceae	60	6	1.83	6.59	8.42
8	Rutaceae	37	5	1.13	5.49	6.62
9	Calophyllaceae	138	2	4.21	2.2	6.41
10	Ebenaceae	135	2	4.12	2.2	6.32
30	Sapindaceae	11	1	0.34	1.1	1.43
31	Piperaceae	10	1	0.31	1.1	1.4
32	Connaraceae	7	1	0.21	1.1	1.31
33	Ancistrocladaceae	6	1	0.18	1.1	1.28
34	Icacinaceae	6	1	0.18	1.1	1.28
35	Burseraceae	3	1	0.09	1.1	1.19
36	Achariaceae	1	1	0.03	1.1	1.13
37	Bignonaceae	1	1	0.03	1.1	1.13
38	Capparaceae	1	1	0.03	1.1	1.13
39	Symplocaceae	1	1	0.03	1.1	1.13
	Total	3277	91	100	100	200

Lauraceae . The family Rutaceae was most superior in terms of species composition (10 species) followed by Fabaceae and Rubiaceae. Among the families evaluated, Rutaceae superceded rest of the families in terms of FIV (16.57) followed by Rubiaceae and Lauraceae. In terms of the importance value index of regenerating diversity of seedlings recorded, *Knema attenuata* was highest in midghat zone (23.52) followed by lower altitudinal zone (Coastal zone) for *Psychotria flavida* and in the upper zone *Murraya paniculata*. However, least was in plane zone for *Syzygium hemisphericum* (0.22).

The evaluation of the components of diversity in three altitudinal zones revealed that the vegetation between 501 and 750 m MSL had higher family composition values (47 families), followed by the midghat zone between 250 and 500 m MSL (41 families), and the coastal zone between 251 and 500 m MSL (39 families) with the lowest values. Rahman et al (2011) also observed that regeneration frequency of both indigenous and exotic species was varied in five different habitats (forest, fallow land, homestead, roadside and others). Among these diversity of indigenous species was highest in forest (36 species), followed by roadside and fallow land while, diversity of exotic species was highest in roadside (12 species), followed by fallow land and forest and indicated that total of fifty-five species in forest had the highest number of species (43 species), followed by roadside (23 species), fallow land (16 species), and homestead (7 species in each). It may due to their different responses to environmental factors.

Size class distribution of regenerating layer: The status and population structure of regenerating individuals of different altitudinal ranges of NTFP species were assessed based on their size class distribution. The size class distribution for all the species in different altitudinal ranges, the decreasing trend of stems of lower size to higher size class exhibiting a reverse J-shape curve graph indicating promising growth of regenerating species {Fig. 1(d)}. In the Coastal zone highest stems were recorded in C-1 (1848) followed by 991, 256 and 182 stems in the size class C-2, C-3 and C-4 respectively which exhibited a reverse J-shape curve graph. Among the regenerating layer, 56.39 per cent of the individuals were occupied by Class-1 followed by Class-2, Class-3 and only 5.77 per cent of stems were in the Class-4 category. In the midghat zone highest stems were recorded in C-1 (1454) followed by C-2, C-3 and C-4 stems in the size class respectively which exhibited a reverse J-shape curve graph. Among the regenerating layer, 54.93 per cent of the individuals were occupied by Class-1 followed by Class-2 . Class-3 and only 5.89 per cent of stems were in the Class-4 category. In the plane zone highest number of individuals were in C-1 (1471) followed by 916, 341 and 261 stems in the size class C-2, C-3 and C-4 respectively which exhibited a reverse J-shape curve. Among the regenerating layer, 49.21 per cent of the individuals were occupied by Class-1 followed

Table 5. Regenerating families of NTFP species at midghat zone (251-500 m)

Rank	Family	No. of individual/ha	No. of species	Relative density	Relative diversity	FIV
1	Myristicaceae	427	3	16.13	3.37	19.5
2	Rubiaceae	289	6	10.92	6.74	17.66
3	Dipterocarpaceae	341	4	12.88	4.49	17.38
4	Myrtaceae	168	7	6.35	7.87	14.21
5	Meliaceae	266	3	10.05	3.37	13.42
6	Arecaceae	162	6	6.12	6.74	12.86
7	Clusiaceae	242	3	9.14	3.37	12.51
8	Rutaceae	78	7	2.95	7.87	10.81
9	Lauraceae	94	6	3.55	6.74	10.29
10	Melastomaceae	67	3	2.53	3.37	5.9
32	Achariaceae	2	1	0.08	1.12	1.2
33	Bignonaceae	2	1	0.08	1.12	1.2
34	Icacinaceae	2	1	0.08	1.12	1.2
35	Salicaceae	2	1	0.08	1.12	1.2
36	Aristolochiaceae	1	1	0.04	1.12	1.16
37	Asperagaceae	1	1	0.04	1.12	1.16
38	Capparaceae	1	1	0.04	1.12	1.16
39	Elaeagnaceae	1	1	0.04	1.12	1.16
40	Lamiaceae	1	1	0.04	1.12	1.16
41	Malvaceae	1	1	0.04	1.12	1.16
	Total	2647	89	100	100	200

by Class-2, Class-3 and only 8.73 per cent of stems were in the Class-4 category.

Based on the overall size class distribution of individuals coastal zone (0-250 m elevation) recorded highest (3277) number of individuals, this may be because of least disturbance in the inaccessible areas (Sharma et al 2017)

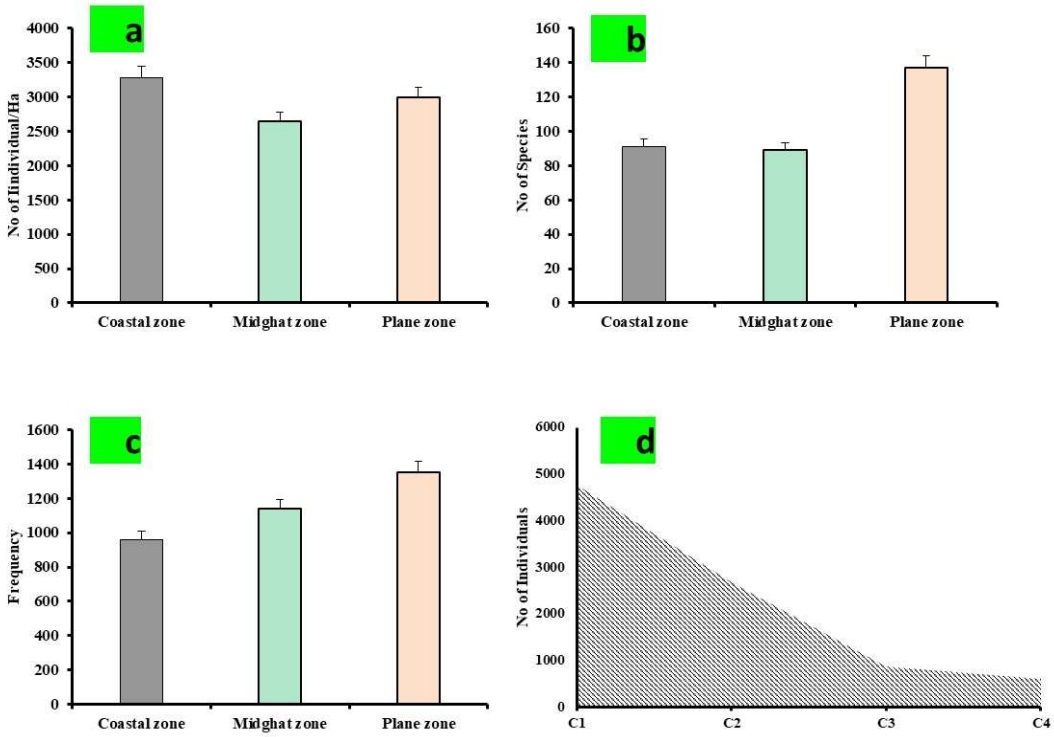

Fig. 1. Variation in Number of individuals per hectare, Number of species observed and Frequency in three altitudinal zones (i.e., a, b, c), Size class distribution of regenerates i.e., C1, C2, C3 and C4 (d)

Table 6. Regenerating families of NTFP species at plane zone (501-750 m)

Rank	Family	No. of individual/ha	No. of species	Relative density	Relative diversity	FIV
1	Rutaceae	277	10	9.27	7.3	16.57
2	Rubiaceae	218	8	7.29	5.84	13.13
3	Lauraceae	216	6	7.23	4.38	11.61
4	Fabaceae	149	9	4.98	6.57	11.55
5	Arecaceae	201	6	6.72	4.38	11.1
6	Combretaceae	150	7	5.02	5.11	10.13
7	Dipterocarpaceae	169	4	5.65	2.92	8.57
8	Euphorbiaceae	175	3	5.85	2.19	8.04
9	Clusiaceae	147	4	4.92	2.92	7.84
10	Myrtaceae	137	4	4.58	2.92	7.5
38	Bignonaceae	5	1	0.17	0.73	0.9
39	Pandanaceae	3	1	0.1	0.73	0.83
40	Annonaceae	2	1	0.07	0.73	0.8
41	Celastraceae	2	1	0.07	0.73	0.8
42	Piperaceae	2	1	0.07	0.73	0.8
43	Burseraceae	1	1	0.03	0.73	0.76
44	Capparaceae	1	1	0.03	0.73	0.76
45	Myrsinaceae	1	1	0.03	0.73	0.76
46	Oleaceae	1	1	0.03	0.73	0.76
47	Salicaceae	1	1	0.03	0.73	0.76
	Total	2989	137	100	100	200

followed by Plane zone (2989 individuals) and least in midghat zone (2647 individuals). This may be due to intensive biotic pressure on them. Collection of fruits or seeds by forest dwellers and tribals for selling as well as for subsistence without leaving fruit or seeds for natural regeneration are another important reason for the poor regeneration (Gunaga et al 2019). Similar observations were also recorded by Murthy et al (2016) and Pandey et al (2016). Rawat et al (2018) in Neora Valley National Park, West Bengal observed maximum individuals in lower dbh class of 10-20cm followed by 21-30cm, 31-40cm, but the least individuals were observed in the highest dbh. Lowest dbh class covered 50.7 percent of total individuals. The reverse J-shaped curve indicates that the forest is showing good regeneration capacity which is a good sign. Similar results were reported by Bharathi and Prasad (2015) in sacred groves of Western Ghats and Prasad and Bharathi (2016) in sacred groves of Virajpet.

CONCLUSION

The midghat zone is rich in regenerating capacity of NTFP species. The study provides useful information on the present condition of regeneration status of NTFP species along different altitudinal gradation. The present study highlights the lower elevational (Coastal zone) NTFP species had comparatively higher number of species, whereas lower number of species was recorded at higher elevational (plane zone) NTFP species, which imply the climatic adaptation by plant species. Altitude affect regeneration status as well as population structure. The fluctuation in population density of seedlings, saplings and adults along the altitudinal gradation may be linked with the environmental factors. The findings of this study will provide the baseline data to assess future migration of species. Vegetation response to recent climatic changes on NTFP species is dependent on initial species composition, vegetation structure and environmental conditions. Hence to reduce pressure on NTFP population, creating awareness among local peoples in harvesting techniques of NTFP species. The findings of present study provide a complete view of regeneration status in the study areas and possess a rich regeneration of NTFPs in the coastal zone.

AUTHORS CONTRIBUTION

Raviraj: Collection of field data and analysis of data, S. S. Inamati: Field analysis of data, M. R Jagadish: Field analysis of data and identification of NTFPs species, B. H. Ganesha.: Analysis of data and writing of manuscript, Rajath Kumar: Analysis of data and writing of manuscript

Received 25 August, 2023; Accepted 11 February, 2024

REFERENCES

Bharathi S and Devi Prasad AG 2015. Regeneration of tree composition in the sacred groves of Mercara, Central Western Ghats. *European Journal of Experimental Biology* **5**(10): 29-40.

Deb P and Sundriyal RC 2011. Vegetation dynamics of an old growth lowland tropical rainforest in North-east India: Species composition and stand heterogeneity. *International Journal of Bio-Inspired Computation* **3:** 405-430.

Getachew T, Demel T, Masresha F and Erwin B 2010. Regeneration of seven indigenous tree species in a dry Afromontane Forest, Southern Ethiopia. *Flora* 205ss: 135-143.

Gunaga S, Radhamani TR and Vasudeva R 2019. Distribution, population and regeneration status of wild edible fruit trees of Uttar Kannada district in central Western Ghats. *International Journal of Forest Usufructs Management* **20:** 15-27.

Henle K, Saree S and Wiegand K 2004. The role of density regulation in extinction processes and population viability analysis. *Biodiversity and Conservation* **13:** 9-52.

Kadavul K and Parthasarathy N 2001. Population analysis of *Alphonsea sclerocarpa* (Annonaceae) in the Kalrayan hills of Eastern Ghats, India. *International Journal of Ecology and Environmental Sciences* **27:** 51-54.

Malik ZA and Bhatt AB 2016. Regeneration status of tree species and survival of their seedlings in Kedarnath wildlife sanctuary and its adjoining areas in Western Himalaya, India. *Tropical Ecology* **57**(4): 677-690.

Murthy IK, Bhat S, Sathyanarayan V, Patgar S, Beerappa M, Bhat PR, Bhat DM, Ravindranath NH, Khalid MA, Prashant M, Iyer S, Bebber DM and Saxena R 2016. Vegetation structure and composition of tropical evergreen and deciduous forests in Uttara Kannada District, Western Ghats under different disturbance regimes. *Tropical Ecology* **57**(1): 77-88.

Negi CS and Nautiyal S 2005. Phyto-sociological studies of a traditional reserve forest Thal Ke Dhar, Pithoragarh, Central Himalayas (India). *The Indian Forester* **131**(4): 519-534.

Pandey K, Adhikari Y and Weber M 2016. Structure, composition and diversity of forest along the altitudinal gradient in the Himalayas, Nepal. *Applied Ecology and Environmental Research* **14**(2): 235-251.

Prasad AGD and Bharathi S 2016. Tree diversity and their regeneration in the Sacred Groves of Virajpet, Central Western Ghats, India. *Notulae Scientia Biologicae* **8**(3): 360-369.

Rahman MH, Khan ASA, Roy B and Fardusi MJ 2011. Assessment of natural regeneration status and diversity of tree species in the biodiversity conservation areas of Northeastern Bangladesh. *Journal of Forestry Research* **22**: 551-559.

Rawat DS, Dash SS, Sinha BK, Kumar V, Banerjee A and Singh P 2018. Community structure and regeneration status of tree species in Eastern Himalaya: A case study from Neora Valley National Park, West Bengal, India. *Taiwania* **63**(1): 16-24.

Runk JV 1998. Productivity and sustainability of a vegetable ivory palm (*Phytelphas aequatorialis*) under three management regimes in north-western Ecuador. *Economic Botany* **52**: 168-182.

Saikia P and Khan M 2013. Population structure and regeneration status of *Aquilaria malaccensis* Lam. in homegardens of upper Assam, NE India. *Tropical Ecology* **54**(1): 1-13.

Sharma CM, Mishra AK, Tiwari OP, Krishan R and Rana YS 2017. Effect of altitudinal gradients on forest structure and composition on ridge tops in Garhwal Himalaya. *Energy, Ecology and Environment* **61**(2): 61-69.